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BIOLOGISTS IN THE MODERN STATE

THE survey of the present and future supply and demand for persons with professional qualifications in biology, agriculture and related sciences, sponsored by the Technical and Scientific Register of the Ministry of Labour and National Service, makes it clear that the supply of graduates in biology may soon outstrip the number of posts available. This survey was recently criticized in *Nature* (**167**, 371; 1951), mainly on the grounds that the function of a university is to provide education at the highest academic level, not merely to provide professional training. But the other aspect of this problem, that is, satisfying the biological needs of the modern State, cannot, for that reason, be wholly ignored.

In the field of pure research, British universities are second to none; but there are still serious drawbacks in applied science. In biology, etc., this can be seen mainly in the type of teaching to which the British university undergraduate is subjected. Physiology, for example, in both our botany and zoology schools, is not so well developed (certainly not so well established) as it is in the universities of some other countries, such as the United States. Too much time seems to be allocated to comparative anatomy in zoology courses; in fact, animal physiology receives almost cavalier treatment. This is reflected in the development of research in agriculture. It might be remedied in due course if students could be persuaded (as suggested in the previous article in *Nature*) to read one biological science and one physical science rather than two biological sciences to honours standard. Improvements in, and expansion of, the teaching of animal physiology could certainly be ensured if our university administrators and teachers would realize more clearly that the need for graduates with a physiological bias in such applications as agriculture would be satisfied by a change in curriculum without undermining the pure academic training of which they are so justly proud. Function is as important as form in the study of living things.

A similar criticism can be levelled at British botany schools. Here, however, one must recognize that there is probably a greater dearth of leading plant physiologists than there is of animal physiologists, and this is reflected in the student training. Plant morphology is now well established; plant ecology is fashionable; plant taxonomy has taken on a new and healthier lease of life. This is all to the good; but plant physiology is equally as important academically and most important technically. Here it is that the British botany schools are lacking in balance.

It is obvious that the biological sciences, just as the physical sciences, must always be ahead of current practice in their applications, for example, in agriculture, medicine and industry. Only in this way can full advantage be taken of opportunities as they arise. Biochemistry, for example, is still in its infancy (in its earliest days, the infant was even

neglected), and its applications have been focused mainly on medical problems with considerable success. It might be that this very success tends to distract the attention of biologists, especially physiologists and biochemists, from those problems affecting industrial production to the solution of which biochemistry could contribute so much. Indeed, there seems to be a real need for a new applied science of biochemical technology, a science which might well, in due course, transform the pattern of food production and food preservation.

In spite of the data supplied by the Ministry of Labour's pamphlet, there can be no doubt that among those working in the wide and varied field of applied biology there is a general conviction that Great Britain and the Commonwealth are at present suffering from a dearth of plant and animal physiologists. For that reason, our control of plant and animal diseases is still rudimentary and empirical in character. The manner of action of many new insecticides and pesticides, for example, is still not known, and until we do understand the basic mechanisms, further progress in this field will continue to be fortuitous and therefore retarded. Over a period of years, plant physiology received considerable stimulus from the investigations of food storage. To-day, many similar and equally important problems cannot yet be tackled because the physiologists are just not available.

This can be rectified only by a new drive at the forefront—our schools of biology (botany and zoology); thus breeding a new style of students who, as already suggested, have read physical sciences cognate with their biological sciences, or who have already had a good grounding in physical sciences before taking up their biological studies.

In this respect, it is possible that the pamphlet issued by the Ministry of Labour might have a seriously deleterious effect on biological teaching and training if taken too literally. Applied problems such as those already cited create their own demands, so the universities should be ready to satisfy them. A static attitude of supplying only known demands is bound to lead to stagnation. This reiterates even what was written in the last paragraph of the previous article in *Nature*:

"Finally, in considering how many biologists we require, it is necessary to consider our strategic position if biological warfare should break out. At present we are exploring only the fringes of biology: consequently the only certainty about biological warfare is that it would be filled with surprises. To cope with the problems involved we need a reservoir of microbiologists, biochemists, biophysicists and cell physiologists. One of the characteristics of this age of planning appears to be to plan to make production equal to current demand, and thus have no reserves for emergencies. It is to be hoped that a wiser policy will prevail in the field of production of scientific workers trained in biology."

Taking up this point only, a group of forty-eight biologists and others in the Departments of Anatomy and Embryology, Botany, Zoology, Physiology, Biochemistry, and Eugenics, Biometry and Genetics, in University College, London, including such names as G. E. Fogg, A. J. Greenbaum, H. Grunberg, J. B. S. Haldane, L. S. Penrose and A. Schweitzer, writes:

"As biologists and teachers of biological subjects we have shared in the general concern at the predicted surplus of biological graduates for the available suitable posts in the next five years. We are, however, even more concerned by one of the suggestions made by yourselves for meeting the situation.

"Your suggestion that a 'reservoir' of trained biologists should be created, to be held against the possibility of the development of means of waging biological warfare, has implications that we feel bound to oppose. In the first place (and this is the point we wish to make most strongly) we cannot reconcile ourselves to the use of our biological knowledge, or that we help students to acquire, for purposes of destruction.

"Secondly it must be pointed out that the 'reservoir' you propose would be offensive in two senses. It would consist of biologists who could not help but be conscious that their professional future depended upon the development of biological weapons. We are sure that many of them would find this an intolerable position. Further, this 'reservoir' could only consist of biologists who were unemployed, misemployed, or underpaid. If this were not so what would tempt biologists from it to work on biological warfare?"

This reaction of the writers seems to be that of idealists ignoring realities. It would be platitudinous here to talk of present-day world conditions, the threats to peace and liberty, the cost of rearmament and defence, and so forth. Such conditions are only too prevalent and, *faute de mieux*, have to be challenged and therefore paid for. Biologists must take their share in this. Moreover, though we still think that a reservoir of microbiologists, biochemists, biophysicists and cell physiologists is needed, it is not even implied that any graduate should have been specifically trained for and eventually directed into it. Neither can we agree with the writers that the reservoir "could only consist of biologists who were unemployed, misemployed, or underpaid". Whether to join such a reservoir or not would be the choice of each individual. While public opinion, as reflected through Parliament and the Government, demands that Britain should bear her strategic position in mind and build up her defences (including preparations for possible biological warfare) it is for the universities to subscribe their special share towards implementing this policy. The universities do not hesitate to supply facilities for training in combating physical and mental disease; there seems no reason, therefore, why similar facilities should not be offered towards combating political disease as exemplified at present by the wearying constant threat of war. If in the event of another world war Britain was found lacking in knowledge of the scientific basis of biological warfare, it would be a serious reflexion on herself, especially in view of the high standard of biological knowledge to which she can justifiably lay claim both for her own men of science and the many others to whom she acts as host and sanctuary. One only asks for such facilities

in view of present world conditions; it must be left to the democratically free student to decide whether he shall take advantage of them.

The writers from University College, London, conclude their communication as follows:

"May we finally express the opinion that there are fruitful fields of work for the expected surplus of graduates which could be developed with real advantage to biological teaching and research in this country."

With this, of course, we agree, and in some of the preceding paragraphs and in the previous article have suggested certain ways and means. But in view of present conditions, it is essential that our biological research and training should be as comprehensive as we can make it.

RISE OF CIVILIZATION IN THE NILE VALLEY

Préhistoire et protohistoire d'Égypte

Par Dr. Émile Massoulard. (Université de Paris: Travaux et mémoires de l'Institut d'Ethnologie, Tome 53.) Pp. xxviii+568+110 plates. (Paris: Institut d'Ethnologie, 1949.) 1800 francs.

THIS is a long-needed summary of the Predynastic period of Egypt, and Dr. E. Massoulard is to be congratulated on having done the task well. Hitherto the only summary available has been the brief one in Petrie's "The Making of Egypt". Dr. Massoulard's work is a more detailed survey, with plenty of references that will be invaluable to students, and it is extended in time back to the Palæolithic and forward to the end of the Second Dynasty, thus logically completing the picture of the rise of civilization in the Nile Valley before written records, and so history, begin. It is also extended in space to include what is known about that restricted bottleneck, Lower Nubia; but it is a pity that Dr. Massoulard was not aware of the excavations of Griffith at Faras and of Oric Bates and Dows Dunham at Gemai in the Second Cataract area. Students of Ancient Egypt must not stop at the frontier of modern Egypt.

The various chapters deal with the Palæolithic, the Mesolithic and Neolithic, the Chalcolithic, the Badarian civilization, the Amratian civilization, the Gerzean civilization, the Maadian civilization, the Protodynastic civilization, the Predynastic and Protodynastic in Nubia, race (physical), political and social conditions, religious beliefs and general résumé.

Published in 1949, the book was written before the appearance of Guy Brunton's "Matmar" and Emery's "Hor-Aha". It makes no claim to be other than a compilation of all that is known from excavations, and if at times the author appears to present conflicting views of very different value without attempting to decide between them, at other times he sums up, and when he does so, it is usually not difficult to agree with his finding.

The first chapter on the Palæolithic and the last chapter on religious beliefs are the least satisfactory. Much has yet to be learnt about the Palæolithic in Egypt. Severe erosion of the country on either side of the Nile Valley renders the study difficult. The doubtful Chalossian culture is given as the earliest, whereas it appears from study of the Second Cataract area that the story begins with the Pre-Chelles–Acheul pebble culture of East Africa which occurs throughout the Nile Valley, associated perhaps with the 150-ft. terrace at the Second Cataract. Acheulian–Levallois is mentioned as a surface association only, whereas Miss G. Caton-Thompson has shown that this hybrid culture occurs at Kharga, as it no doubt does elsewhere; and the term 'Mousterian' is unfortunately retained in a special sense for what is now known everywhere as Levalloisian. No account is taken of Miss Caton-Thompson's important papers on "The Levalloisian Industries of Egypt" (1946) and "The Aterian Industry" (1947); and it is due to a misprint that it is stated (on p. 19) that Sebilian III occurs *below* Sebilian II. Vignard's suggestion that the Sebilian II people ground cereals, because they had lower grindstones stained with red ochre, is correctly rejected.

Little is yet known about the Mesolithic in the Nile Valley; but it must have occurred in places. Dr. Massoulard is right in stating that desiccation only became serious with the rise of the Amratian, and it is probable that before that period the Nile Valley in Egypt was bordered with mosquito-ridden papyrus swamps and therefore uninhabited, a small population inhabiting the bordering steppe (now desert). My own excavations[1,2] have brought to light a late Mesolithic culture and an early Neolithic one derived from it, both in the Khartoum area, the former with pottery decorated with impressed designs to resemble basketwork, designs which also occur in the lowest known levels at Mersin in west Asia and in Upper Kenya Capsian. The two cultures previously known from Egypt, Sebilian III and Helwan, the latter connected with the Natufian of Palestine, have in common with Early Khartoum and the Kenya Capsian geometric microliths, which proclaim the descent of all from the Capsian of North Africa.

The rise of the Neolithic must have been a lengthy process in which the various inventions, pottery, agriculture, polished stone tools, the domestication of different animals, etc., were gradually diffused through the Fertile Crescent and its neighbourhood. Dr. Massoulard is right in deciding that none of his authors had found the origins of the Neolithic in Egypt, and he inclines towards the view that it probably came from west Asia. I agree with him that the cultivation of cereals and domestication of cattle and the dog came from there, entering the Nile Valley at its northern end, while the invention of pottery in a centre as yet unknown (possibly in west Asia) certainly did not first reach the Delta but rather the Nile upstream of the Sixth Cataract, having perhaps crossed the southern end of the Red Sea from Asia; but Esh Shaheinab, with its many features common to the Fayum Neolithic and yet some striking differences, suggests that the polishing of stone tools and the domestication of the goat may have reached the Nile Valley in the Khartoum area from the west via Tibesti.

Dr. Massoulard reasonably concludes that the similarities in the Amratian and Gerzean are due to their common heritage from the Neolithic, and postulates two continuous lines of development: Tasian–Badarian–Amratian in Upper Egypt, and Fayum Neolithic–Merimda–Gerzean in Lower Egypt. The latter is probably the result of the mating of the new ideas from Tibesti with others from west Asia

in the region of the Delta, which was continually in touch with Asia and possibly conquered by Asiatics during the Gerzean. The former, although also inspired by the new ideas from Tibesti, is shown by the Esh Shaheinab excavation to be more a native product of the Nile Valley with black-topped red, black incised, and rippled pottery and disk maceheads, all invented and evolving in the upper Nile Valley and perhaps east of it, until a branch of it produced the local Tasian–Badarian in the river valley in Upper Egypt. The Badarians were probably in touch with west Asia, obtaining from there small copper tools, glazed steatite beads and the idea of the mother goddess. Contact with Asia presumably accounts for the occurrence of silver and lapis lazuli objects in late Amratian and also the representation of a Mesopotamian boat on a cross-lined sherd from Mostagedda.

The Gerzeans with many more Asiatic contacts probably conquered Upper Egypt, possibly under a dynasty of Asiatic conquerors (Jebel el Arak knife), although there is no archæological evidence to support Sethe's theory that the Gerzean capital of united Egypt was Heliopolis. It was probably during this period that the first religious ideas entered the Nile Valley from the east, the home of hawking, the falcon on its perch that flew high and far and dealt death to its quarry being taken by a Gerzean chieftain as his totem, and coming to be associated with the sun and the sky in which it flew, and so developing into Horus. The fertility cow-goddess of Iraq with the sacred byre surmounted by her symbol also presumably developed into Hat-hor, the 'house' or spouse of Horus. On the palette of Narmer she is represented by her head on either side of an early form of the *serekh*, on which the kings of Egypt thenceforward wrote their names, and which is presumably the Egyptian form of the god's shrine developed out of the sacred byre. It is usually surmounted by the hawk, because the king was the representative on earth of the divine hawk Horus. The hitherto inexplicable 'Bull's head' amulet of the Predynastic probably had an Asiatic origin connected with the amulets from Tepe Gawra which represent either the reed shrine with the crowning symbol of Ishtar or the mother goddess herself. Dr. Massoulard's last chapter shows the need for a special study of the rise of religious beliefs in Egypt; and it is suggested that it is somewhat on the above lines that it will probably be found to have taken place. The female figurines with raised arms and the similar representations of women on decorated pots are no doubt dancing, as Dr. Massoulard decides, and dancing the cow dance (sacred to Hathor) as some Dinka women still do on the Upper Nile to-day, their arms representing horns.

The summary of Dynasties 0–II is good; and the analysis of the extent to which this brilliant period (when many of the features characteristic of the historic civilization of ancient Egypt were evolved) was indebted to the Gerzean, the local genius of Egypt or to influences from Asia, is masterly.

Many comments on details in a detailed summary of such a long period could be made but would make this review inordinately long. It is no doubt due to costs of production that the paper of the book is of poor quality, and the numerous illustrations consist of outline copies from pictures in other publications. Of these the drawings of stone implements are often unsatisfactory, and on Plate CIII the illustrations of Figs. 13 and 14 have been omitted. There are also a number of misprints in the text which should not have occurred.

It is, however, an important work for which Egyptologists and prehistorians will be grateful, and which it is to be hoped will soon be emulated in English.

A. J. Arkell

[1] "Early Khartoum" (Oxford University Press, 1949).
[2] "Esh Shaheinab", *Proc. Prehistoric Soc.*, 42 *ff.* (1949).

DO THE CHROMOSOMES FIT THE SPECIES?

Die Chromosomenzahlen der gefässpflanzen Mitteleuropas

Von Prof. Dr. Georg Tischler. Pp. 263. ('s-Gravenhage: Dr. W. Junk, 1950.) 80*s*.

THIS book does for Central Europe what the Merton Catalogue did for Great Britain in 1930: it provides a list of the chromosome numbers of the species of vascular plants in the region. The 2,224 species recorded represent about 73 per cent of the total officially recognized, and of these about half are polyploid.

Prof. Tischler's method is to follow the official systematic arrangement—as did the Merton Catalogue—fitting the chromosome observations into it. From the bibliographical point of view this would seem to be the correct approach. Certain difficulties, however, have now become clear, partly as a result of Prof. Tischler's enterprise in making chromosome lists. Indeed, the discovery of polyploidy within species which already involves more than ten per cent of official species, and will in the end probably involve a majority of them, makes it impossible to continue fitting in the chromosome observations to the pre-existing classification. The attempted subordination therefore conceals the essential value of the chromosome counts, which depends on the fact that they destroy the classical notion of species.

Take a simple example. If we read that a cytologist gives the chromosome number of *Prunus avium* as 16, we have no right to say that *P. avium* L. has 16 chromosomes. The initial of Linnæus inserted here is a piece of bogus scholasticism unless the same person who counted the chromosomes also compared his material with Linnæus's description; and any attempt to do that in each case would obviously hamstring all further inquiry. What actually happens, however, is that the initial of the authority is added by the botanical compiler who takes it out of a book. The scientifically significant connexion is that established between a plant which falls within the range of variation usually allowed to the sweet cherries and the diploid number of chromosomes. Cherries with the tetraploid number are usually less sweet. They include all forms ascribed to *P. cerasus* L. and also some that Linnæus might have called varieties of *P. avium*. The truth, the shocking truth, is that to-day anyone who is working with cherries or cabbages or wheats, or almost any other group that has been well studied, finds out the chromosome number first and deduces the class into which the plant falls from the number. Otherwise, he is likely to be wasting his time.

Looking at a more complicated case, when the user of this book finds that *Crocus vernus* Wulf has 8, 10, 16, 20, 24, 25, 30, 32 or 35 chromosomes, he may ask himself what Wulf would have thought of these

observations if he had seen the plants the properties of which are here recorded. But he may also ask what Wulf would have thought of his species in the light of these observations. Here is a species that has been well studied. But what of the majority, where only one plant has been examined? It is true that in some cases we may still attempt to attach the chromosome number to a species; but already in as many other cases we have to identify the species by the chromosome number.

The systematic and nomenclatural straightjacket, into which Prof. Tischler and others attempt to squeeze our genetic understanding of species, in fact squeezes the life out of it. Scholastically the result looks neat and elegant; but, if it is required to work, we find that the thing inside is dead. Prof. Tischler's list is an invaluable compendium for future workers. His immense bibliography enables the reader to trace every reference; and his industry puts on record data for which all those concerned with the European flora should be grateful. But to the systematist it does not give an idea of how chromosome numbers are actually varying at the present moment, or of the way in which the nineteenth century notion of species, however bolstered up by bibliographical conventions, is now going to pieces under the impact of genetic and cytological analysis.

C. D. Darlington

WATER BEETLES OF GREAT BRITAIN

British Water Beetles

By Frank Balfour-Browne. Vol. 2. (Ray Society Volume 134, for the Year 1948.) Pp. xx+394. (London: Bernard Quaritch, Ltd., 1950.) 27*s*. 6*d*.

THIS volume completes a work of considerable interest to students of British Coleoptera and of British aquatic fauna alike. It deals thoroughly with the Colymbetina, Dytiscina and Gyrinidæ both from a biological and systematic point of view.

Excellent determination tables are given to run down to species, and some good use is made of the more obscure characters. For the most part, Prof. F. Balfour-Browne has constructed them on different ground from that used in the work of the Rev. W. W. Fowler and that of Dr. N. H. Joy; he gives more detail than the latter, and is far more up to date than the former.

Each species is discussed at length with regard to structure, habitat, distribution, life-history and systematics. Much attention has been paid to the genital armature, which can be of great assistance in determination, especially in the genus *Gyrinus* where it is of use in eight species. These have been very well figured by both male ædeagus and female genital lobe. The structure of the insects is perhaps dealt with in more detail than the average reader will require, but is by no means out of place. Entomological biologists will be pleased to see the work on larvæ, and a useful table down to genera is given.

The work is very well illustrated with diagrams and camera lucida drawings clarifying a number of points which otherwise might remain obscure. A distribution map is provided for each species.

In his introduction (pp. xiii–xiv) the author has some pertinent remarks to make on the Code of Zoological Nomenclature, Article 25, to which he does not rigidly adhere; but since he gives a very full synonomy in each case, no confusion need arise. On p. xviii he condemns the naming of varieties and aberrations with insufficient knowledge of the association between that variety or aberration, its typical form, its type of habitat and the climatic conditions, etc. Fig. *A* shows two good examples of variation, one towards the other, of typical forms, and named aberrations in the genus *Agabus*. These two points, I feel sure, will receive the support of many workers in this field, which will not necessarily be confined to those primarily concerned with biology.

A copious bibliography of nearly four hundred titles completes a work which commends itself to all interested in British water beetles. F. D. Buck

WAVE-MOTION AND SOUND FOR THE HONOURS STUDENT

Wave Motion and Sound

By Dr. R. W. B. Stephens and Dr. A. E. Bate. Pp. viii+448. (London: Edward Arnold and Co., 1950.) 45*s*. net.

THERE is need for a text-book on sound that covers the many advances that have been made in recent years, and this book fills the requirement admirably. It deals with the subject at a level appropriate to a university degree course, and gives adequate references for the more detailed reading required in research.

The first part of the book is concerned with the fundamental properties of wave motion, starting with periodic motion in general, and continuing with transverse and longitudinal vibrations, reflexion, refraction, diffraction and resonance. The later part is concerned with applications of the earlier theory—physiology, music and architectural acoustics. All these sections are dealt with exhaustively, and, where mathematical analysis is possible, it is given fully, either in the text or in one of the appendixes (which number thirty and cover seventy-eight pages). Nearly one hundred examples of examination questions, with numerical answers, are also included.

It will therefore be appreciated that the authors have spared few pains to make the book a success, and there is little doubt that it will be of benefit to those in universities who deal with the subject of sound. It is therefore unfortunate that the authors have occasionally thought it necessary to introduce subjects at pre-university level; the first few pages of certain chapters might well discourage the more serious reader. For example, the chapter on periodic motion begins in a very elementary fashion, and a quasi-calculus proof is given (p. 15) of the expressions for the velocity and acceleration of a particle moving with simple harmonic motion. Yet, a few pages later (p. 37), second-order partial differential equations are introduced. This is perhaps the most glaring example of inconsistency in level of treatment, but other examples could also be quoted; for example, the subject of resonance is introduced by quite elementary considerations. The reviewer believes that a text-book should state quite clearly, as this book does, what standard of tuition is aimed at, and that there should then be no necessity for the authors to 'write down' to readers who have not attained this standard.

This, however, is a minor cavil in a book which is undoubtedly very welcome. H. Lipson

BRITAIN'S SCIENTIFIC SHRINES (I)

By Eng.-Captain EDGAR C. SMITH, O.B.E., R.N.

FOR every traveller Great Britain presents a rich field for exploration; whatever his tastes, there is enough and to spare. Every village, every town, every city has its own tale to tell, while dispersed throughout the country are innumerable prehistoric sites, remains of Roman settlements, churches, cathedrals, castles, mansions, galleries and libraries. Societies and institutions, national and local, often with their own collections, abound, and with all this wealth awaiting the inquirer, there are agencies whose business it is to supply information of every kind, so that visitors to Britain in this Festival Year may become acquainted with the activities of our fellow men, both past and present, in their varied fields of endeavour. In this connexion it has been considered appropriate that attention should be directed to the homes and haunts of eminent men of science, their monuments and memorials, wherever they are to be found, thus providing information which may be of use to visitors with scientific leanings as they travel the countryside. Within the limits imposed, such a survey of the byways of science must necessarily be a partial one; but further notes will generally be found in guide books, county histories, the proceedings of local societies and the like, while it is only just to say that inquiries made to our public libraries seldom fail to receive the most careful consideration.

There are various ways in which such a survey of the byways of science as is proposed can be carried out; but that chosen is to deal with the counties in small groups, beginning with the southern counties, then with the eastern counties and so forth; but before travelling into the country, a few notes are given here about London, for it may be remarked that for the visitor to the Festival of Britain Exhibition, London itself offers perhaps the most varied feast of all. From the Tower of London in the east to Westminster Abbey in the west, in the City of London and the City of Westminster, and the adjacent districts, many a lane, many a street, many a building recalls an episode in the history of science in Britain. The great County of London of to-day, created only in 1888, is very different from the London of Harvey or Newton or Banks, and stretches from Woolwich to Hammersmith, embracing two cities, the Royal Borough of Kensington and no fewer than twenty-six other boroughs. It has absorbed parts of Kent, Surrey, Middlesex and Essex; but it is the older London with which these notes are mainly concerned.

LONDON

The oldest scientific institution in London is the Royal College of Physicians, which has its headquarters in Pall Mall East. Its foundation in Tudor times was due to Thomas Linacre (1460 ?–1524), physician to Henry VIII, and its first home was in Linacre's house in Knight Rider Street, just south of St. Paul's Cathedral. In those days, old St. Paul's was still standing, and in it Linacre was buried and later commemorated by a memorial erected by Dr. John Caius (1510–73), the benefactor of Gonville Hall (which was renamed Gonville and Caius College), Cambridge. Tomb, memorial and cathedral were all destroyed by the Great Fire of 1666, but Linacre's fame is imperishable. The companion institution, the Royal College of Surgeons, which has its headquarters in Lincoln's Inn Fields, has a much shorter history; but it has its roots in the old corporations of Barber-Surgeons. In 1745, however, the barbers and surgeons became distinct corporations, and so arose the Masters, Governors and Commonalty of the Art and Science of Surgeons in London, the parent of the Royal College. One notable event in the history of the College was the acquisition of the anatomical collections of John Hunter (1728–93), whose death occurred with tragic suddenness at St. George's Hospital. Though no one can point to the spot where Linacre was buried, Hunter's remains lie in the north aisle of the nave of Westminster Abbey, whither they were transferred at the expense of the Royal College of Surgeons through the extraordinary exertions of the naturalist Frank Buckland (1820–80), the son of the geologist William Buckland (1781–1856), sometime Dean of Westminster. In January and February 1859, Buckland spent many days in the vaults of St. Martin-in-the-Fields, moving coffin after coffin until on February 22 he found Hunter's. Buckland was ill after his exertions, but recovered, and on March 28 attended the re-interment of the coffin in Westminster Abbey. Another famous man buried in St. Martin-in-the-Fields was Robert Boyle; but that was before the present church was built, and to-day Boyle is as one of those who have no memorial.

After the founding of the College of Physicians in 1518, the next scientific institution to arise in the City of London was Gresham College, which has now been active for more than three hundred and fifty years, and still provides courses of public lectures by its professors of astronomy, geometry, music, physic, civil law, divinity and rhetoric. Sir Thomas Gresham (1519 ?–1579), the Elizabethan magnate, before he died had given London its first Royal Exchange, and by his will he bequeathed to the City and the Mercers Company his mansion in Bishopsgate Street for a College. The bequest became available after his widow's death, and in 1596 Edward Brerewood (1565 ?–1613) began lecturing on astronomy, and Henry Briggs (1561–1630) on geometry. The College, which in different circumstances might have blossomed out into a university, counted among its early professors Gunter, Rooke, Gellibrand, Greaves, Barrow, Hooke and Wren, and it was the meeting of some of these in the College, contemporary with meetings of others at Oxford, which led to the formation in 1660 of the Royal Society. The first recorded meeting of the Society took place in the College on November 28, 1660, and except for a brief period after the Great Fire, the College was the home of the Society for fifty years. Nothing of the old mansion remains to-day; but a visit to St. Helen's Church, Bishopsgate, in which is the monument to Gresham and the graves of some of the professors, will recall something of the old-world atmosphere of those seventeenth-century days. It was in the apartments of the Gresham professors that Boyle exhibited his air pumps, Wren talked on astronomy, Petty on shipping, and Wilkins on natural standards; that Evelyn became curator of insects, and Papin demonstrated his pressure cooker. Newton was elected a fellow and Hooke lived, worked and died there, and from it his remains were carried to St. Helen's Church.

After about half a century of this close connexion between College and Society, difficulties arose with the Mercers Company, mainly through the bad state of the buildings, and the Society sought new quarters, thus beginning its journey westwards, first to Crane Court, Fleet Street, to premises of its own which it occupied from 1710 until 1780, then to Somerset House, in the Strand, to quarters provided by George III, and finally in 1857 to the fine mansion of the Earls of Burlington in Piccadilly, which had been purchased by the Government for £140,000. Many alterations and additions have been made to Burlington House, which to-day houses not only the Royal Society, but also the Society of Antiquaries, the Royal Academy, the Linnean Society, the Royal Astronomical Society, the Geological Society, the Chemical Society and the British Association for the Advancement of Science.

Of other scientific institutions in London with long histories, a word or two should be said about the Royal Society of Arts, which dates from 1754, and the Royal Institution, founded in 1799, for they were formed, not so much with the object of furthering the progress of a particular science, but for contributing to the welfare of mankind. The former, known first as the Society of Arts, was founded "for the Encouragement of Arts, Manufacturers and Commerce", its promoter being William Shipley (1714–1803), a drawing master who established "Shipley's Academy" in the Strand. The Society held exhibitions of pictures before the Royal Academy, promoted agriculture before the Royal Agricultural Society, encouraged chemical research before the Chemical Society, and stimulated invention by medals and money prizes. In 1843 Prince Albert became its president, and the list of recipients of its Albert Medal rivals the list of the Copley medallists of the Royal Society, its roll of honour including the names of Pasteur and Madame Curie from France, Bunsen and Helmholtz from Germany, Marconi from Italy, and Edison and Michelson from America.

Even more than the Society of Arts, the Royal Institution owed its foundation to the spirit of philanthropy, for Count Rumford was ever for the betterment of the poorer classes, the improvement of their domestic appliances and the furtherance of their craftsmanship. Of the inauguration of this world-famous Institution, the fluctuations in its fortunes and the careers of its first professors and lecturers—Garnett, Young, Davy and Faraday—an account was given by Dr. Bence Jones in his book "The Royal Institution", published in 1871. For a historian of science it is as fascinating reading as Weld's "History of the Royal Society", published in 1848. By 1871, Faraday had been dead four years, but his mantle had fallen on the shoulders of John Tyndall, and their work and that of their successors, Frankland, Gladstone, Rayleigh, Dewar, Bragg and others, form one of the brightest pages in the history of science in Great Britain. But it is a mistake to think of the Royal Institution solely in terms of science, for its lecture theatre has resounded, and still resounds, with the voices of men distinguished in many other spheres. Sir Benjamin Thompson, Count von Rumford (1753–1814), who was knighted by George III and made a Count of the Holy Roman Empire by the Elector of Bavaria, and was dubbed by Gibbon "Mr. Secretary-Colonel-Admiral-Philosopher" Thompson, began life as a British colonial, having been born in North Woburn, Massachusetts, and first came to England when twenty-three years of age. It was this that led Prof. Florian Cajori, of California, in his "History of Physics", to write: "It is pleasant to contemplate that while the Royal Institution was founded by an American, the Smithsonian Institution in Washington owes its origin to an Englishman".

To another category of scientific institutions belong our great national museums. In its early days the Royal Society formed collections of which Nehemiah Grew in 1681 published a catalogue of 435 pages and 31 plates dedicated to Daniel Colwall, the founder of the collections. Apparently, one specimen described by Grew, "a frontlet of the West African dwarf buffalo (*Syncerus nanus*)", still survives in the British Museum (Natural History). There were other collections in private houses and even in some London coffee houses; but our modern museums begin with the purchase by the Government of the library and collections of Sir Hans Sloane, and the opening of the British Museum in 1753. Among these collections were birds, insects, fossils, minerals and a herbarium preserved in 334 large folio volumes. The present Natural History Museum, completed in 1880, at South Kensington, is still an integral part of the British Museum, which will soon be commemorating its bicentenary.

At South Kensington are also the Victoria and Albert Museum, which is descended directly from a museum of manufactures founded after the Great Exhibition of 1851, the Science Museum—the national museum of science and industry—and the Geological Museum, the direct descendant of the Museum of Practical Geology opened in 1851 in Jermyn Street. Histories of science concern themselves mainly with the great discoverers and pioneers; but the most cursory glance at the catalogues of these museums with their millions of exhibits shows how the progress of science is indebted to thousands of men and women who in one way or another, by their studies, their travels, their collecting and their writings, have added their contributions to the great structure of science of to-day; and in the museums are found some of their noble gifts to the country.

An almost forgotten chapter in the scientific annals of London centres around the old coffee houses and taverns. At the Rainbow Coffee House in Watling Street in 1721 was a botanical society, presided over by the German professor John James Dillenius; to the Grecian Coffee House in Devereux Court, Strand, the fellows of the Royal Society would adjourn after their discussions in Crane Court. Childs, Slaughters, the Bedford and the Salopian coffee houses all figure in the memoirs of the eighteenth century, as also do the Chapter Coffee House, in St. Paul's Churchyard, where a chemical club used to meet, and the London Coffee House, Ludgate Hill, where Priestley presided over a social and philosophical club. Notable among such gatherings were those of the old Royal Society Club, known in its early days as "the Club of the Royal Philosophers". Watt was entertained at one of its gatherings by Cavendish, Blagden and Smeaton, and afterwards wrote: "Never was turtle eaten with greater sobriety and temperance or more good fellowship".

Wander where he will in London, the visitor is never far from some spot with scientific associations. In the Tower, Flamsteed made observations before Greenwich Observatory was built; at the Mint, close by, Newton, Sir John Herschel and Thomas Graham all held the mastership, while Faraday and Tyndall made investigations for Trinity House. In the

old Charterhouse, now rising from the ruins of war, Stephen Gray, the first of all Copley medallists, made his remarkable electrical experiments when he was well over seventy. Not far away, in Newgate Street, stood Christ's Hospital, the 'Blue Coat School', now finely housed at Horsham, Sussex. In the seventeenth century it had a mathematical school, two of the scholars from which went to Russia with Peter the Great; one was murdered and of the other nothing is known.

All around Fleet Street were the shops of the clock and instrument makers, and in St. Bride's Church was a memorial to Dr. Charles Wells, known for his investigations on dew. St. Paul's Cathedral is not only the resting-place of Mylne, who built Westminster Bridge, and Rennie, who designed old Waterloo Bridge and London Bridge, but also the great Sir Christopher Wren himself. Not so many years after his death, experiments were made in the Cathedral with falling bodies released from the dome.

Many a house, many a street having associations with the scientific worthies of old London, have disappeared; but a visitor, if he wishes, can make a pilgrimage with the aid of a "List of Houses of Historical Interest in London Marked by Memorial Tablets", obtainable from the Record Keeper of the London County Council.

No scientific pilgrimage in London, however, would be complete without a visit to Westminster Abbey, where among the hundreds of tombs, statues, tablets and other memorials are some forty to fifty to men of science of the past three hundred years. The first of these to be buried in the Abbey was Sir Robert Moray (d. 1675), the earliest president of the Royal Society; the last was Lord Rutherford, whose ashes were buried on October 25, 1937, in the nave close to the graves of Newton, Sir John Herschel, Kelvin and Darwin. Not far from these in the centre of the nave lie Telford, Robert Stephenson, Tompion, and George Graham. In the north aisle of the choir near by is a remarkable group of tablets and medallions to Lord Lister, A. R. Wallace, Darwin, Sir George Stokes, Joule, Sir William Hooker, John Couch Adams and Sir William Ramsay. With a copy of the official guide to the Abbey, it is easy enough to find any particular grave or monument or memorial window. Chantrey's £6,000 statue of Watt is to be found in St. Paul's Chapel, Baily's statue of Telford in St. Andrew's Chapel, where also are the memorials to Davy, Thomas Young, Sir James Young Simpson, Dr. Matthew Baillie and to the third Baron Rayleigh (1842–1919), "an unerring leader in the advancement of natural knowledge". Periodically there is a somewhat half-hearted demand that some of the many memorials in the Abbey should be removed; but it was Dean Stanley who wrote that Westminster Abbey is endeared to the nation not so much that it is the scene of the coronations or the sepulchre of kings, but "that it is the resting-place of famous Englishmen from every rank and creed, and every form of mind and genius". There is no 'Valhalla' like the Abbey anywhere else in the world, and not even the Père la Chaise Cemetery in Paris surpasses it in its interest for the man of science. There are scores of famous British men of science and engineers—such as Roger Bacon, Francis Bacon, Gilbert, Ray, Harvey, Cavendish, Priestley, Huxley, Owen, Gilbert White, William Herschel, George Stephenson and Smeaton—whose memorials are not in the Abbey, and it will be one of the objects of this survey to show where they are to be found.

DECLINE AND DEATH OF BACTERIAL POPULATIONS*

By Sir CYRIL HINSHELWOOD, F.R.S.

Introduction

FROM certain points of view the bacterial cell may advantageously be regarded as the seat of a complex pattern of chemical reactions, the rules of combination of which determine many of the characteristic properties[1]. The enzyme reactions constitute a sort of production-line; the functioning of the enzymes must be linked with their own synthesis, and the building of proteins and of nucleic acids is interrelated in such a way that each appears dependent on the other[2]. A multiplicity of simple substrates are utilizable by the cell, but lags and delays attend the switching from one to the other. Similar lags occur before synthesis is resumed after an interruption, since inactivated enzymes require to be repaired and the intermediate metabolites which pass from one section to another of the production-line have to attain once more their proper concentrations. When an adaptive switch from one set of growth conditions to another is imposed, the enzymatic constitution of the cell undergoes changes of limited amplitude, short of mutations but important in themselves. Indeed, there is good reason to believe that there is an automatic adjustment to that set of proportions which will allow the reaction pattern corresponding to an optimum growth-rate.

When the growth of a culture stops and the cells cease to multiply, there is no reason to suppose that the machine is very much more quiescent than when visible autosynthesis is proceeding. Oxidations, deaminations and other specific enzyme reactions are brought about readily by suspensions of non-growing cells; when actual increase of mass ceases at the end of the logarithmic phase, transformation of ribose nucleic acid into deoxyribose nucleic acid seems to continue for a time[3]; and indeed the whole trend of modern experiments on the exchange of radioactive tracer elements seems to show that the making and unmaking of the cell material continues at a lively rate in most living cells even when the balance of these two processes gives no net increase in substance[4]. Although linked for the purposes of growth, individual enzyme reactions occur to some extent autonomously, since they are called forth by the provision of the appropriate substrate more or less in isolation.

When, however, bacterial cultures are not given opportunity for renewed growth, the population tends to decline, the death-rate of the cells being, of course, accelerated by adverse circumstances such as the presence of toxic substances. The law of decline not infrequently approximates to the exponential form $n = n_0 \exp(-\lambda t)$, n_0 being the initial number, n the number at time t and λ a constant. This law has occasioned much discussion[5]. Taken as exact, it implies that the death of a cell is governed by a chance event independent of the previous history; and various authors have regarded this event as an accidental encounter between some sensitive component of the cell and a molecule of the toxic agent. In particular, the lethal effects of radiation have been interpreted in terms of encounters between quanta and sensitive targets in the structure of the living material[6].

* A sequel to "Chemistry and Bacteria" (*Nature*, Dec. 30, 1950).

Although the experimental validity of the exponential decline law has been often challenged, it is probably a good enough approximation in many cases to be significant. Nevertheless, the encounter theory has many unsatisfactory features, especially the assumption that the cell organization is so dependent upon intensely localized key structures that a single quantum—or a single molecule of a poison—could disrupt it. The limited series of multiple hits which is sometimes postulated still presents a good deal of difficulty from this point of view.

It seems opportune, therefore, to consider the question of the whole reaction pattern of a cell economy in decline, and to inquire whether an alternative interpretation is possible.

Reaction Pattern of the Cell in Decline

In the resting state of the cell, the various enzyme activities gradually decay, and eventually the cells become non-viable. In the later stages of decline lysis may set in (sometimes very readily, as with *B. subtilis*). Under the influence of ultra-violet light, various functions of the cell are first impaired—sometimes quite specifically so that mutants result'—and then complete dissolution of the material occurs.

The correct picture of this degenerative process is almost certainly more complex than the encounter, or bullet, theory implies. Lysis must be the irreversible completion of reactions which at first were kept in balance by synthesis, and represents the failure to maintain an equilibrium in the perpetual process of making and unmaking cell material.

Suppose the raw material for fresh synthesis is withheld. The slow decay of certain parts of the cell sets in, and at different rates in different enzymatic areas. There is, in effect, a partial internal lysis. The products of this constitute, however, nutrient matter themselves, and since the cell economy is mostly intact, will be largely caught up on their way out and re-processed. In a sense, as some parts of the cell decay, they must create a new internal medium for the synthetic reactions of the machinery as a whole. Fragments lost from one enzyme may well be salved by another; and although the net result is decline, the dissolving economy is fighting to maintain itself with many constructive weapons.

As has been said, adaptation to a new medium leads to a change in enzyme proportions, and during the partially disorganized struggle to salve decay products and re-synthesize material, some parts of the enzyme substance may at any given stage fare better than others. Some may, indeed, increase at the expense of others which are more selective in their demands. In the complex interlocking system of synthetic and degradative reactions, the proportions of different enzymatic types must almost certainly vary. In view of the ease with which in some cases eventual lysis occurs, it may even be that certain parts of the decaying structure acquire phage-like properties and may increase by direct attack on others.

Fluctuations

The result may be an actual waxing and waning of individual parts of the cell machinery. Consider the following idealized example of two enzymes (or units of the cell mechanism). Suppose the first (X) produces a product which attains a concentration c_1 governed by the equation

$$dc_1/dt = k_1x - k'_1c_1 = 0,$$

where x is the amount of X. This product attacks lytically enzyme Y, which decays thereby at a rate k_2yc_1, that is, $(k_2k_1/k'_1)xy$. Y, however, is being re-built from other sources, so that

$$dy/dt = k_0c_0y - (k_2k_1/k'_1)xy. \qquad (1)$$

The decay of Y yields fragments which are avidly mopped up by X, their concentration in the cell attaining a value c_2 such that

$$dc_2/dt = (k_2k_1/k'_1)xy - k'_2c_2 = 0.$$

The rebuilding of X is proportional to c_2 and thus to $(k_2k_1/k'_1k'_2)xy$.

Therefore,

$$dx/dt = (k'_0k_2k_1/k'_1k'_2)xy - k''_0x. \qquad (2)$$

(1) and (2) may be written

$$dx/dt = axy - bx \qquad (I)$$
$$dy/dt = \alpha y - \beta xy. \qquad (II)$$

These are, in fact, Volterra's well-known equations, applied originally to populations of predatory species and prey in certain conditions, and they have the property of yielding periodic solutions. x and y can wax and wane with time.

Multiplication of (I) by β and of (II) by a and addition yields

$$\beta\frac{dx}{dt} + a\frac{dy}{dt} = a\alpha y - \beta bx.$$

Multiplication of (I) by α/x and (II) by b/y and addition yields

$$\frac{\alpha}{x}\frac{dx}{dt} + \frac{b}{y}\frac{dy}{dt} = a\alpha y - \beta bx.$$

Subtraction of the last two equations gives

$$\beta\frac{dx}{dt} + a\frac{dy}{dt} - \frac{\alpha}{x}\frac{dx}{dt} - \frac{b}{y}\frac{dy}{dt} = 0;$$

whence $x^{\alpha}y^{b}.\exp(-\beta x).\exp(-ay) = A$, where A is a function of the initial values x_0 and y_0. According to this solution, different values of A correspond to a series of *closed curves* in the x,y plane, so that x and y are both periodic functions of the time.

Volterra's equations would only apply strictly in rather special circumstances; but in quite a variety of conditions they would apply in an approximate way, and over a certain period of time. There is, in fact, no permanent cycle established because decay is progressive, but superposed on this there will probably be fluctuations.

Other sets of conditions than these which are expressed by the differential equations (I) and (II) may also lead to waxing and waning in certain cell functions. As has been said, the balance of synthetic and degradative processes continues the struggle to maintain itself in an internal medium which differs from that of the original growth, and new combinations of individual reaction-steps come into play. Whenever this occurs, as, for example, when an inoculum of cells is transferred to an entirely fresh medium, there is the possibility of a lag phase during which new kinds of intermediate gradually rise in concentration. If, now, the various combinations of synthetic process are attended with lags, certain parts of the repair mechanism may fail for a time to function at more than a small fraction of the possible rate, and only gradually reach the state where they can do so. They will then be consuming not only the

intermediate, which was increasing towards the optimal concentration, but also other substances as well. The removal of these will have an adverse effect on various competing repair processes. In this way oscillatory changes may be set up.

Consequences of the Fluctuations

The fluctuations which may be set up in ways similar to those referred to in the last section will not, of course, be truly periodic oscillations, but will, for a certain time, roughly approximate to these. They will be *multiple*, since various pairs of enzymes can enter with one another into the relation of predatory system and prey—or of source and sink of material. The multiple periodicities will be in some measure independent of one another, and their phases, moreover, will be random. The randomness of the phases is important and comes about in the following way. At the moment when the growth of a culture ceases—whether from exhaustion of nutrient material or from the accumulation of toxic substances—the individual members of the population will be at all stages between one cell division and the next. The operation of the factors limiting the growth of the culture bears no relation to the stage of any individual cell-cycle. Thus variations in the cell-composition will occur from one individual to another. These are likely to affect enzymatic proportions, as well as absolute amounts, since the constant composition which is established in a culture growing under standardized conditions is only an average taken over the cycle of each cell.

If, then, there are independent quasi-periodicities with random phases, there will be a certain probability that, in a given cell in a given short interval of time, specified combinations of enzymatic functions pass through their maxima or minima together. This probability will be independent (in so far as the periodicities themselves are independent and the phases strictly random) of the previous history of the system. In this respect the conditions are mathematically analogous to those which must govern the law of decay of the atoms of a radioactive element[8].

Viability

It might reasonably be assumed that when certain functions of the cell in the fluctuating process of decline and recovery simultaneously pass through a minimum, then no further restitution is possible and the cell ceases to be viable.

If this very natural postulate is correct, the chance that the death of a cell should occur during a time interval between t and $t + dt$ is proportional only to λdt, where λ is constant, and, in particular, independent of t. The viable population will follow the law

$$-dn/n = \lambda dt,$$

whence $n = n_0 \exp(-\lambda t)$, where n_0 is the number living at time $t = 0$. This expression is, of course, the well-known law of logarithmic decline.

Here it follows from the postulate not of a random encounter of a lethal agent (as bullet) with a sensitive area (as target), but from that of an appropriate *conjunction* of independent events.

Consideration of the Logarithmic Law

According to the foregoing, this law follows as a consequence of assumptions which are only approximately true. But the law itself is only approximately true. It remains to be seen whether the deviations are of the kind to be expected[9].

The principal types of deviation are: (*a*) the death-rate of the population is initially lower than the law predicts; (*b*) the final stages of decline are abnormally protracted.

In (*a*), the curve of log (number of survivors) against time shows a sigmoid form. This means, in effect, that with many cells a definite period of time elapses before the lethal factors attain their full force. Such a delay indicates a progressive and cumulative action on the cell, and is what might have been expected had there been no waxing and waning in the vital functions of the kind described above. In so far as the periodic phenomena discussed are superposed on a general decline, the result is not an improbable one. We have only to assume that until a certain stage in the general decay of the cell economy has been reached, even an adverse combination of the quasi-periodic factors does not necessarily preclude recovery.

As to (*b*), the most obvious explanation of a long tail to the curve of survival would be the presence of a proportion of cells with abnormally great resistance. Such cells might originate from the interruption of growth at the appropriate moment. It is by no means inconceivable that at certain phases of the individual cell-cycle there is a maximum resistance, the internal structure passing through a condition at some stage where it bears the maximum resemblance to a resistant spore. In sporulating bacteria there is, of course, the well-defined stage in the cycle of vegetative cell – spore – vegetative cell where resistance is that of the spore. Although non-sporulating bacteria do not pass through this morphological phase, they may well pass through one where the internal configuration approaches that which would be attended by sporulation in other species. However this may be, there is in any event the possibility and even probability of the occasional cell of abnormal resistance. (In this connexion it is of interest to note that Fraser[10] finds bacteria to be much more easily disrupted by sudden release of dissolved gas just at the end of the logarithmic phase than later in the stationary phase. It may also be observed that, according to Hollænder, Stapleton and Martin[11], the sensitivity to X-rays of *Bact. coli* is a function of the conditions of previous growth, especially of those affecting the state of oxidation or reduction inside the cell.)

The resistant survivors may further have arisen from previous mutations, whereby a small proportion of a specially endowed sub-strain has been introduced into the population. If the mutation has been profound enough, these cells might not merely survive but also actually proliferate in presence of a toxic agent which kills off most of the others. The eventual growth by an alternative metabolic route might also occur if certain cells survived long enough to pass through the lag phase which almost invariably attends a switch in the growth-mechanism. Here we should have an actual adaptive response.

All these and other factors can be invoked to account for the deviation from the logarithmic law. Indeed, the real problem is not why it is inexact, but why it is ever even approximately applicable. To dismiss it as the simple expression of a particular statistical distribution of survival-times among the cells leaves open the question why so wide a distribution should exist, and the analogies which have

been suggested in this discussion offer an explanation of this very remarkable circumstance. From the chemical point of view, such an interpretation seems more natural than any form of target theory.

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[9] See especially Clark, A. J., *loc. cit.*
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EDINBURGH MEETING OF THE BRITISH ASSOCIATION

THE 113th meeting of the British Association will be held in Edinburgh during August 8–15. This will be the sixth time the members have met there. The first meeting was so early as 1834, and the most recent the meeting of 1921. Edinburgh's connexion with the Association goes back even earlier than 1834, for the first suggestion for the formation of such a body was made by Sir David Brewster in an article in the *Quarterly Review*, and in 1831 he was one of its chief originators.

The president this year is H.R.H. the Duke of Edinburgh. On two previous occasions a member of the royal family has presided at a meeting of the Association: at the Oxford meeting of 1926 the Duke of Windsor (then Prince of Wales), and at the Aberdeen meeting ninety-two years ago the Prince Consort, whose name recalls at once the Great Exhibition of 1851, the centenary of which we are this year celebrating in the Festival of Britain. In a sense, indeed, this year's British Association meeting will be a part of the Festival.

The inaugural meeting will take place in the McEwan Hall on the Wednesday evening, when the Duke of Edinburgh will deliver his presidential address on "The British Contribution to Science and Technology in the Past Hundred Years". Before the address, the president will receive from the University the honorary degree of doctor of laws. The proceedings will be relayed to an overflow meeting in the Usher Hall.

The retrospect of the past hundred years will be one theme (but by no means the only theme) running through the week, and several presidents of sections propose to speak of a century of their special subject (and Sir Claude Gibb in Section G on "Two Thousand Years of Engineering"!). Most, however, are looking forward as well as backward, like Sir Hector Hetherington in Section L ("Retrospect and Prospect"), or Sir Cyril Hinshelwood in Section B ("Chemistry at the Midcentury").

Scotland and Scottish subjects naturally take a prominent place in the programmes. Dr. D. A. Allan will lecture on "The Scottish Scene", there are papers on Scottish population, on the movement of miners, on the geology of the Lower Forth and the Scottish metamorphic and granitic rocks, on Celtic art, and other Scottish topics. Just as, last year, Birmingham was anxious to let it be known that parts of the Black Country are quite green, so this year Edinburgh is anxious to make it clear that she is not distinguished only for learning and law, but is also now an important industrial centre, as the list of excursions to factories shows. Other excursions range over half of Scotland, to Loch Sloy, the Tummel, the Bass Rock, Strathyre and (after the meeting) a geological field-trip to the Mull of Kintyre. These are only a few.

There are to be, as usual, several joint sessions of two Sections, for example, Physiology and Chemistry, to discuss "Hormones of the Pituitary"; and what is not usual, a whole-day joint meeting of no fewer than nine sections to discuss surveys of underdeveloped areas.

The three evening discourses are by the Very Rev. John Baillie on "The Impersonality of Science as a Discipline for the Spiritual Life"; by Sir Edward Salisbury on "The Contemplative Gardener" (surely a charming title); and by Prof. John Read on "Alchemy and Alchemists", which is charming in another sense, for it is believed that Prof. Read will play records of medieval charms, sung by a choir of St. Andrews students. These are, it is said, the words and their tunes once used by magicians to turn rivals into toads, or base metals into gold. We understand, however, that no untoward events occurred at the rehearsals—no toads, and, alas, no gold.

Another lecture will be about a modern magician—Sir Edmund Whittaker's lecture on Eddington's principles in the philosophy of science. It is not so very far from abracadabra to the mysterious numerical relationships of physical measurements; and we have, after all, actually transmuted metals. There will, by the way, be a discussion in Section A on "Nuclear Physics in Scotland".

Sessions likely to be found intensely interesting by specialists include one on probability in Section A*, on the storage of farm products in Section M, and on advances in taxonomy in Section K. Section J is devoting four meetings to "Current Trends in British Psychology: Occupational, Social, Educational, and Clinical". At an open meeting on the evening of August 13, the Division for Social and International Relations of Science will deal in particular with the international effects of radio communication and of travel by air.

All meetings are within a few minutes walk of each other and of the Old Quadrangle: and there are arrangements for lunches and teas, though Edinburgh can scarcely vie with 1834, when a preliminary paragraph in *The Scotsman* said: "We hear the ordinaries are to be brilliantly attended. Contributions of venison and game have been received from various quarters, and fat bucks from both sides of the Border have been submitted for scientific discussion." On the social side, there will be a civic reception on the Thursday evening (August 9), and a University reception on Saturday evening (August 11), numerous section dinners, the Council's dinner for overseas and local guests, a conversazione by invitation of the scientific societies in Edinburgh, and a smaller reception by the Royal Society of Edinburgh. The president of the Royal Scottish Geographical Society and Mrs. Bartholomew are giving a garden party at Inveresk.

On Sunday morning (August 12) there will be a special service in St. Giles' Cathedral, conducted by the Very Rev. Charles Warr, minister of St. Giles'

and Dean of the Chapel Royal in Scotland and of the Order of the Thistle. The sermon will be preached by Prof. Donald M. Baillie, of the University of St. Andrews. Representatives of the City and of the University will also be present.

A list of the sectional presidents and the titles of their addresses appeared in *Nature* of April 7, p. 547. Further information can be obtained from the Secretary of the British Association, Burlington House, Piccadilly, London, W.1, or from the Local Secretaries, 3, Buccleuch Place, Edinburgh, 8. A provisional programme is already available, and a full programme giving detailed arrangements will be published about July 10.

NEWS and VIEWS

Royal Society : Election of Foreign Members

The following have been elected foreign members of the Royal Society : Prof. Herbert McLean Evans (Berkeley, Cal.), distinguished for his researches in anatomy, embryology and particularly in the field of experimental endocrinology ; Prof. Karl Spencer Lashley (Cambridge, Mass.), distinguished for his studies of the neurological basis of animal behaviour and of the factors involved in learning ; Dr. Carl Fredrik Störmer (Oslo), distinguished for his researches on the motion of charged particles in magnetic fields and on auroral phenomena ; and Dr. Ralph Walter Graystone Wyckoff (Bethesda, Md.), distinguished for his contributions to the study of viruses.

Forestry at Edinburgh : Prof. E. P. Stebbing

It has recently been announced that Prof. E. P. Stebbing will retire from the chair of forestry in the University of Edinburgh at the end of the current session. Thus will terminate a very remarkable record in university forestry teaching, as Prof. Stebbing became the lecturer in forestry more than forty years ago when in 1910 he succeeded Colonel Bailey ; in 1920 the lectureship was raised to a chair, with Prof. Stebbing as the first occupant. He went to Edinburgh from India after seventeen years of work in the Indian Forest Service, having devoted most of the latter part of that time to entomology. Although entomological work was gradually crowded out after his return to Great Britain, he has always retained very great interest in Indian forestry, and we owe to him an outstandingly valuable history of the forests of India, a very large undertaking in three volumes, aggregating nearly 1,900 pages. Prof. Stebbing has long been a very ardent advocate of the conservation of vegetation for the protection of soil and water supply, and has taken an active part in directing public attention to the consequences of denudation by overgrazing and injudicious clearing for cultivation, particularly on desert fringes such as those of the Sahara. This interest, together with his Indian experience of forest organization, protection and management, may be said to have provided the keynotes of his teaching, with his very wide first-hand knowledge of the forests of several continents. The outstanding features of his methods would appear to be the stress laid on some of the practical aspects of the professional forester's work, such as engineering and surveying, and on the value of what might be termed the orthodox or Continental working plan for management ; he has not been in favour of any extension of the fundamental scientific training which would involve lengthening the course or displacing items of the established undergraduate syllabus. As a teacher, Prof. Stebbing's influence on forestry must have been comparable with that of his own instructor, William Schlich, particularly in Great Britain and in the Colonies, in view of the large numbers of forestry students who have passed through his hands over so long a period.

Rumford Premium of the American Academy of Arts and Sciences : Dr. H. E. Ives

The American Academy of Arts and Sciences has awarded the Rumford Premium for 1951 to Dr. Herbert E. Ives, of Upper Montclair, New Jersey. The Premium was founded by the Academy in honour of the American-born scientific worker, Benjamin Thompson, Count Rumford, and is awarded every second year in recognition of important discoveries in heat and light. Dr. Ives was with the Bell Telephone Laboratories during 1919–47 and has made outstanding contributions to optics, including the first accurate determination of the visibility function of the average human eye, scientific methods of colour measurement and specification, and other developments in the physics of light measurement. His practical applications in photo-electricity include the development in the Bell Telephone Laboratories of a method of sending photographs over telephone lines, now in general use by newspapers, and a demonstration (in 1927) of television over long distances by wire and radio. Dr. Ives is a former president of the Optical Society of America and a vice-president of the American Association for the Advancement of Science.

Optical Society of America : Honorary Members

The Optical Society of America announces in the editorial to the February number of the Society's *Journal* (41, 63 ; 1951) that Profs. R. A. Millikan and A. Sommerfeld have been elected to honorary membership of the Society. In the citations it is stated that Prof. Millikan's most important contributions to optics have been in the photo-electric determination of Planck's constant and in the extension of spectral measurements by the condensed spark vacuum spectrograph. He is best known for his work on the photo-electric effect and on the electronic charge, for which he received the Nobel Prize in 1923. Perhaps not so well known is that he, together with C. R. Mann, in 1902, first translated Drude's "Theory of Optics" into English. For Prof. A. Sommerfeld, emeritus professor of theoretical physics in the University of Munich, who is now in his eighty-fourth year and still continues to be active in scientific work, his classic book "Atombau und Spektrallinien" is quoted as sufficient evidence for the award, though mention is also made of several, among a very long list, of famous physicists who have been his pupils at one time or another.

Museums of Nature and Man

Dr. A. E. Parr, director of the American Museum of Natural History, New York, introduced a stimulating discussion at the recent biennial conference of

the International Council of Museums in London on the place of natural history museums in the natural sciences and in the general cultural life of the community. The paper was published in the *Museums Journal* (November 1950). Dr. Parr maintained that the very great developments in physiology, experimental biology and other subjects not dependent upon museums naturally altered their function in the world of science. The introduction of zoological gardens, photography and the cinema have created other media for depicting Nature which did not exist when the arrangement in museums was determined. It is rightly maintained that the needs of the specialist and the demands for the education of the public are basically different. In relation to research it is essential that some type of intelligently planned and sensibly executed division of labour should be arranged so that the specialist will not need to waste so much of his time tracing material sources. In this connexion it would be natural for each institution to concentrate its efforts on becoming a complete source, in material and information, for its own region. In addition, the larger institutions should, by agreement, be responsible for particular divisions of the natural sciences. In the designated subject their collections should be as complete as possible. It is also necessary for museums to emphasize that they deal not only with the form of the dead but also with the life of the living. They are rapidly becoming the chief centres of ecological research. From the point of view of the average member of the public, it is true to state that he is not so much interested in undisturbed or wild life as it exists in Nature, but rather in the environment of man. This then is the field in which the educational efforts of the natural history museums should make their greatest contribution to human thought, welfare and progress to-day. This stimulating paper by Dr. Parr is commended to specialists as well as those interested in the visual education of the community.

Bibliography of Political, Economic and Social Aspects of Atomic Energy

In 1949, the Atomic Energy Commission Group of the Department of Security Council Affairs (United Nations Organization) issued a printed edition of "An International Bibliography on Atomic Energy. Vol. 1: Political, Economic and Social Aspects", of which preliminary versions had appeared earlier as mimeographed documents. Several important books and articles reflecting individual views and public discussion, in addition to a series of United Nations documents, have appeared since, and these have necessitated a supplement to Vol. 1 (Supplement No. 1. Pp. v+22. Lake Success, N.Y.: United Nations; London: H.M. Stationery Office, 1950. 1*s*. 9*d*.). This supplement deals with the literature in the English and Russian languages published during the period March 1949–June 1950, inclusive. It is hoped to issue at a later date a new edition of the bibliography incorporating additional, as well as the present, material. In the contents, 275 separate items are listed under the following headings: international control; national control and development; peaceful uses of atomic energy; military uses and defence measures; social, economic, political and ethical implications; and general descriptions of atomic physics. Each item contains the name of the author, the original title (with a translation if in a foreign language) and the reference, and in most cases a summary or quotation from the article. The historian, the social scientist, and those interested in the technical aspects of nuclear energy and civil defence will find the bibliography most interesting and useful.

Fracture of Metals

The refresher courses organized by the Institution of Metallurgists have obtained a high reputation. Until 1949, however, these lectures were not published; but those given at the course in that year on "The Fracture of Metals" have been published by the Institution (pp. 138; 12*s*. 6*d*.) and form an admirable summary of knowledge regarding such fracture under all the main conditions of service. Of the six papers included in this volume the first, by Dr. N. P. Allen, of the National Physical Laboratory, provides a most excellent summary of fundamental knowledge regarding cohesion and rupture in metals. It is a curious fact that our knowledge of the circumstances in which metals break is considerably less than that regarding those at which plastic yielding sets in, and of the conditions which lead to ductile or brittle fracture, respectively, knowledge is at present highly imperfect. With this paper as a background, the others deal with specific aspects of the problem of a more practical and engineering nature. Dr. R. W. Bailey discusses fracture due to creep, and H. L. Cox rupture under fatigue. The effect of stress corrosion in leading to failure in engineering parts is dealt with by Dr. U. R. Evans, the effects of the rate of loading on fracture by Dr. C. Gurney, and brittle fracture in mild steel by W. Barr. Each of these is in its own way an almost ideal summary, as would be expected from men each of whom in his own line can speak with outstanding authority. This little book, in fact, represents one of the most interesting publications in the realm of engineering metallurgy which has appeared in Great Britain for some time.

Experimental Parasitology

A new quarterly journal, *Experimental Parasitology*, published by Academic Press, Inc., of 125 East 23rd Street, New York 10, N.Y., will be launched this summer, with Dr. D. R. Lincicome, of Stine Laboratories, Newark, Delaware, as managing editor, and an editorial board composed as follows: Drs. H. H. Anderson, T. von Brand, E. Bueding, A. C. Chandler, E. C. Faust, Q. M. Geiman, G. van Grembergen, C. G. Huff, A. Lwoff, J. Oliver-Gonzalez, C. B. Philip, W. P. Rogers, J. D. Smyth and N. R. Stoll. Original papers dealing with the experimental approach to problems in the field of parasitology will be considered for publication, and contributions that involve experimental aspects of physiological, metabolic, biochemical, nutritional and chemotherapeutic problems of parasites and host-parasite relationships are especially desirable. In addition to original research material, a section of the periodical will be devoted to "Parasitological Reviews", which will consist of review articles prepared by invitation of the editors and covering all aspects of the field. Manuscripts may be submitted to the managing editor or to any member of the board of editors.

Electrical Engineering Course for Aeronautical Students

The College of Aeronautics, Cranfield, is starting a two-year course in electrical engineering, the aim of which is to give postgraduate students a grounding

in general aeronautical engineering, together with a more specialist training in those branches of electrical engineering which find application in the aeronautical field. The electrical side of the instruction will be divided in five sections: applied electronics, communications, aircraft electrical systems, servo-mechanisms and aerials. Students should possess a degree or Higher National Certificate in mechanical or electrical engineering or a degree in physics; but these conditions may in certain circumstances be waived. Further details can be obtained from the registrar of the College, at Cranfield, Bletchley, Bucks.

Ferreyra Institute of Medical Research

The ceremony was held last month of the opening of the new building for the Instituto de Investigación Médica Mercedes y Martín Ferreyra, at Casilla de Correo 389, Córdoba, Argentina. The building is a memorial to Dr. Martín Ferreyra and his wife and is the gift of their children. Dr. Bernardo A. Houssay, of Buenos Aires, and Dr. Charles H. Best, of Toronto, Canada, were present and gave special addresses. The Institute is a private one devoted to scientific research into the fundamentals of medicine, and the present director is Dr. Oscar Orías.

Pollution of the River Thames: Departmental Committee

The Minister of Local Government and Planning has appointed a departmental committee with the following terms of reference: "To consider the effects of heated and other effluents and discharges on the condition of the tidal reaches of the River Thames, both as at present and as regards any proposed new developments in the area, and to report". The members of the committee are as follow: Prof. A. J. S. Pippard (*chairman*), A. Bird, L. Cleaver, A. N. East, A. N. Gardiner, Dr. H. Hollings, Dr. A. Key, Prof. D. N. Newitt, F. T. K. Pentelow, J. L. Reading, R. Llewellyn Rees, C. J. Regan, J. S. Smith, Dr. B. A. Southgate, W. P. Warlow, B. R. White and G. A. Wilson. The secretary of the committee is A. R. Isserlis, the Ministry of Local Government and Planning, Whitehall, London, S.W.1, to whom all communications should be addressed.

A Recent Sunspot

A big sunspot group of rather complex formation has recently been an interesting telescopic object on the solar disk. If it had been seen through mist or light fog, the spot should have been conspicuous to the unaided eye. Passing into view round the east limb on April 12 in lat. 13° N., the group reached the central meridian on April 18.8 U.T. with an area not far short of 2500 millionths, or 1/400 of the sun's hemisphere. This is the largest spot since February 1950, but the sunspot cycle is now well past its maximum phase and probably within some three years of minimum. Up to the time of this report (April 21), only minor solar flares have been seen associated with the region by spectroscopic observers in Great Britain. However, a radio fade-out on short-wave reception suggests that a flare of moderate intensity occurred on April 12, and another of greater intensity on April 19 at 05h. 30m. to 06h. 30m. U.T. So far, only a small geomagnetic storm has occurred, namely, on April 18–19, the magnetic traces at Abinger being most disturbed between 10h. and 18h. U.T. on April 18.

The Night Sky in May

New moon occurs on May 6d. 01h. 35m., U.T., and full moon on May 21d. 05h. 45m. The following conjunctions with the moon take place: May 2d. 18h., Jupiter 3° S.; May 4d. 22h., Mercury 5° S.; May 9d. 17h., Venus 3° S.; May 16d. 22h., Saturn 4° N.; May 30d. 10h., Jupiter 4° S. Mercury is a morning star but is too close to the sun to be observed. Venus, an evening star, sets at 23d. 05m., 23h. 20m. and 23h. 25m. on May 1, 15 and 31, respectively, and is conspicuous in the western sky, stellar magnitude −3·6, the visible portion of the illuminated disk varying from 0·74 to 0·62. Mars is in conjunction with the sun on May 22 and is too close to the sun for observation. Jupiter, a morning star, rises at 3h. 35m., 2h. 50m. and 1h. 50m. on May 1, 15 and 31, respectively. Saturn is an evening star and sets in the early morning hours at 3h. 35m., 2h. 40m. and 1h. 35m. on May 1, 15 and 31, respectively. Only one occultation of stars brighter than magnitude 6 takes place in May, *c* Leon. disappearing to observers at Greenwich on May 15d. 20h. 08m.

Announcements

Dr. Edward Hindle, who is just retiring from the post of scientific director of the Zoological Society of London, has been awarded the Isidore Geoffroy-St. Hilaire Medal of the Société Nationale d'Acclimatation de France, in recognition of his many zoological investigations of particular interest to the Society.

The Walker Prize of £100 for 1946–50 has been awarded to Prof. Alexander Haddow, professor of experimental pathology in the University of London and director of the Chester Beatty Research Institute, for his many notable contributions in the field of chemotherapy of cancer, for his leadership and organization in directing a great institute for cancer research, and for the high regard in which he is held by cancer research workers in Great Britain and abroad.

The Division of Physical and Inorganic Chemistry and the Division of Colloid Chemistry of the American Chemical Society is arranging a symposium on "Complex Ions and Polyelectrolytes", to be held during June 18–20 at Cornell University. The programme will cover the following six topics: equilibrium aspects of complex ions, kinetics of complex ions, aggregation reactions in solution and at higher temperatures, properties of synthetic polyelectrolytes, proteins, and ion exchange resins. Further information on the symposium will be published in the near future in *Chemical and Engineering News*. Registration for attendance must be received by May 20. All inquiries should be directed to Dr. R. K. Osterheld at the Department of Chemistry, Cornell University, Ithaca, New York.

A one-day conference, organized by Aslib (Scottish Branch), will be held in the rooms of the Royal Society of Edinburgh on May 25 during 10 a.m.–5.30 p.m., and will be open to members and non-members of Aslib alike. Speakers will include Miss M. Herbison, Joint Parliamentary Under Secretary of State for Scotland; Dr. D. J. Urquhart, on "The Department of Scientific and Industrial Research as a Source of Information"; Dr. V. E. Parke, on "An Intelligence Officer in Industry"; and Mr. Leslie Wilson, on "Aslib". Further particulars can be obtained from the Honorary Secretary of Aslib (Scottish Branch) at 37 Ann Street, Edinburgh.

RETINAL RECEPTORS

DARTNALL'S report[1] of the discovery of two new retinal pigments does not seem to us to rest on convincing evidence. Hartridge[2], writing from the same Institute, carries so far what we believe to be fallacious reasoning that the matter requires to be discussed.

The statement is made that "the crests of the known (retinal) pigments are separated by equal frequency intervals"; this is described as a "fundamental observation". In support of it are quoted Hartridge's fixation points: 660, 620, 580, 540, 500, 460 and 420 mμ ($\Delta\lambda = 40$). Also in support are quoted the Hartridge subjective colours: 640, 610, *575, 540*, 510, 480, 450 and 420 mμ ($\Delta\lambda = 30$ or 35). If there is a constant wave-length difference there cannot be a constant frequency difference. In any case, there appear to be *two* constant wave-length differences, namely, 30 and 40 millimicrons. Granit's micro-electrode wave-lengths, 600, 580, 540, 500, 480, 460 and 420 mμ, are also quoted in support. Here wave-length differences of both 40 and 20 millimicrons recur. In this case there is neither constant wave-length difference nor constant frequency difference. Granit's electro-polarization data with wave-lengths 610, 520 and 450 mμ are also quoted in support, but do not agree with any one of the three sequences.

The group of retinal pigments, the absorption peaks of which are said by Dartnall[1] to fall into a series separated by a constant frequency difference, may now be discussed one by one:

(*a*) Iodopsin 570 mμ. The very existence of this pigment as a separate entity is doubtful and the exact position of its maximum as given does not compel assent.

(*b*) Visual violet (porphyropsin) occurs in those eyes in which vitamin A_2 partly or wholly replaces vitamin A_1: λ_{max} is usually given as 522 mμ and is not very accurately known[3,4].

(*c*) Visual purple (rhodopsin) 502 mμ is by far the best-known retinal pigment and occurs in 'vitamin A_1' eyes.

(*d*) Visual red 475 mμ has a doubtful and inferential existence, as the following experiment shows. A solution of cattle rhodopsin prepared from isolated rods was allowed to bleach to the extent of 80–90 per cent and the absorption spectrum was measured at this stage. The solution was then allowed to bleach completely and the difference spectrum shown in Fig. 1 obtained. It is known that intermediate products of the bleaching of rhodopsin (for example, transient orange and acid indicator yellow) absorb in the region 440–480 mμ[5–7], and it is fair to conclude that the peak shown in Fig. 1 corresponds to a mixture of these products and of unbleached *iso*-rhodopsin[5]. As cattle are believed to have only rods in their retinas, it is hard to think that cone pigments are detectable in these extracts.

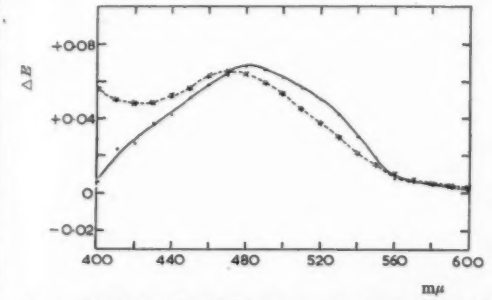

Fig. 1. Rhodopsin (dissolved in 1 per cent aqueous digitonin) was bleached by a 60-watt lamp until only about 10–20 per cent remained. The absorption spectrum was then measured. The solution was then completely bleached and the absorption again measured. The curves show the differences before and after complete bleaching. Curve II (— × — × —) is derived from a less 'pure' solution of rhodopsin than curve I (— · — · —)

(*e*) Visual yellow 2, 407 mμ, cannot be accepted as a retinal pigment until confusion with the Soret band of hæm pigments is ruled out. In his communication, Dartnall[1] makes no comment on the presence in his curves of a narrow band at about 410 mμ which, without evidence to the contrary, must be taken to correspond to the well-known Soret band of hæm pigments. That the visible bands of a hæm pigment are not clearly defined in Dartnall's figures is no doubt due to the fact that such bands have only about one-tenth the intensity of the Soret band.

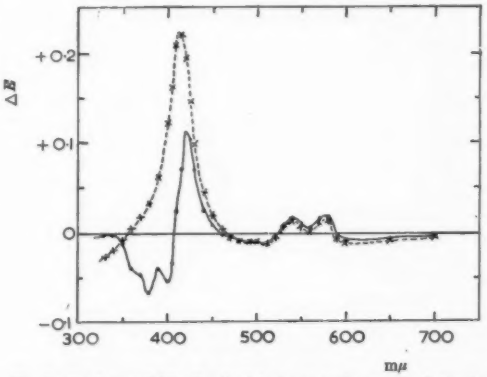

Fig. 2. Oxyhæmoglobin dissolved in 1 per cent aqueous digitonin (optical density at 415 mμ, near 0·85) and left for two hours. The curves show the difference in the extinction before and after this period. Curve I (— · — · —) oxyhæmoglobin only. Curve II (— × — × —) oxyhæmoglobin plus pure retinene. A positive value of ΔE indicates that the absorption has *decreased* by that amount —this is to conform with Dartnall

Digitonin solutions, used to extract the visual pigments, increase in turbidity on standing[4]. This increase is quite slow (and is delayed in the presence of additional protein), but in an hour or so is appreciable. The absorption spectrum of a solution of oxyhæmoglobin in one per cent digitonin solution (optical density at 415 mμ = 0·85) was measured with the fresh solution and after allowing the solution to stand for two hours. The two sets of measurements did not coincide, and the difference spectrum is shown in Fig. 2. Presumably some of the oxyhæmoglobin had been adsorbed on to the slowly precipitating digitonin. Similar peaks in difference spectra have been obtained when solutions of rhodopsin containing hæm pigments have been allowed to stand in the light for some hours. Such peaks have never in our experience been obtained in the absence of hæm pigments.

We conclude, therefore, that the peaks which Dartnall believes to be due to new photosensitive

pigments can be explained without the necessity of postulating new pigments. Before the claims for new photosensitive pigments can be regarded as substantiated, the effects to which attention has been directed should be shown to be absent.

Even granting Dartnall's series, there are twenty-five separate wave-lengths submitted as characteristic of eight receptors. The mean differences between the wave-lengths and those in Dartnall's series are 1 ± 8 mμ (S.D.); for $P = 0{\cdot}95$ the fiducial limits are $17{\cdot}5$ to $-15{\cdot}5$ mμ and the wave-length differences in the series vary between $46{\cdot}9$ and $27{\cdot}5$ mμ.

It follows that the evidence for a constant frequency difference is quite inadequate.

It is, of course, well known that in some series of polyenes, $R(CH{=}CH)_nR'$, the spectra are displaced for every successive increment in n. An approximate application of quantum mechanical principles to polyenes leads to the prediction of two alternative relationships between λ and n [8]. Either λ^2 or λ is a linear function of n, depending on the type of molecule. The "quantum theory basis" referred to by Hartridge may possibly recall the constant frequency differences which appear in the partly resolved spectra of, for example, benzene, ergosterol or aqueous potassium permanganate. These are, of course, due to quantized vibrations, and the constant frequency difference is a manifestation of vibrational fine structure within a single molecule. As Hartridge mixes up eyes using vitamin A_1 and vitamin A_2, he clearly cannot be thinking in these terms. Indeed, he suggests by way of illustration that the retinal pigments might differ by one, two or more hydroxyl groups and that such a scheme "would provide a series of related pigments with an equal frequency interval between them". Such a statement could not be defended, and the expectation that this kind of argument "should lead to the recognition of the chemical structure of them all" (retinal pigments) is unduly optimistic.

Hartridge also states that the "yellow pigment with a crest at 475 mμ . . . is a carotenoid, related to xanthophyll, $C_{40}H_{56}O_2$. If this be true, the relationship between this visual pigment and vitamin A is established." Against this, however, we submit that there is overwhelming evidence that xanthophyll is not a provitamin A.

The physiological investigations of Hartridge, Granit and others are, of course, indispensable in any synthesis of knowledge in this difficult field. We are here only concerned to point out that conclusions based on the recent communications of Dartnall and of Hartridge on the subject require re-examination.

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R. A. Morton

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University, Liverpool.

[1] Dartnall, H. J. A., *Nature*, **166**, 207 (1950).
[2] Hartridge, H., *Nature*, **166**, 820 (1950).
[3] Wald, G., *Documenta Ophthalmologica*, **3**, 94 (1949).
[4] Collins, F. D., and Morton, R. A., *Biochem. J.*, **47**, 3 (1950).
[5] Collins, F. D., and Morton, R. A., *Biochem. J.*, **47**, 18 (1950).
[6] Wald, G., Durell, J., and St. George, R. C., *Science*, **111**, 179 (1950).
[7] Berger, P., and Segal, J., *C.R. Acad. Sci., Paris*, **230**, 1903 (1950).
[8] Maccoll, A., *Quart. Rev. Chem. Soc.*, **1**, 16 (1947).

Prof. Morton and Dr. Collins point out correctly that the values which were obtained by the fixation point method, namely, 660, 620, 580, 540, 500, 460 and 420 mμ, form a perfect series which has a constant wave-length difference, and they, therefore, correctly conclude that these figures cannot have a precise constant frequency difference. But there are two points which I should like to make. The first is that the values which I have published are correct to two significant figures only. In other words, the experimental error of the fixation-point method is so large, so far as wave-lengths are concerned, that it is unlikely that the precise crest wave-lengths of the receptors in question are obtained with an accuracy better than 5 mμ. In fact, the error may be larger than this, particularly where the ends of the spectrum are approached. The second point is that even if certain figures do form a perfect wave-length difference series, they may still approximate, within experimental error, to a constant frequency difference series. In fact, calculation shows that the average discrepancy between the experimental and calculated values on a frequency basis corresponds to $7{\cdot}0$ mμ.

Prof. Morton and Dr. Collins also quote the values I obtained by the subjective colour method, these being 640, 610, 575, 540, 510, 480, 450 and 420 mμ. Now in this case also the method is affected by large errors, and it is doubtful whether the values given correspond to the true wave-lengths of the crests of the receptors with an accuracy better than 5 mμ. In this case the values are found to differ from a constant wave-length difference series by $3{\cdot}4$ mμ and from a constant frequency difference series by $6{\cdot}1$ mμ.

It is seen, therefore, that both in the case of the fixation point method and of the subjective colour method the values obtained are, within experimental error, in conformity with an equal frequency difference series (see Table 1). The fact that they are also within experimental error in conformity with an equal wave-length difference series does not disturb this conclusion.

Table 1

A Fixation-point method	*B* Subjective-colour method	*C* Mean values of *A* and *B*	*D* Equal frequency differences	*E* Differences between *C* and *D*
660 mμ	640 mμ	650 mμ	657·1 mμ	7·1
620 ,,	610 ,,	615 ,,	610·2 ,,	4·8
580 ,,	575 ,,	578 ,,	569·6 ,,	8·4
540 ,,	540 ,,	540 ,,	534·1 ,,	5·9
500 ,,	510 ,,	505 ,,	502·7 ,,	2·3
—	480 ,,	480 ,,	474·9 ,,	5·1
460 ,,	450 ,,	455 ,,	449·9 ,,	5·1
420 ,,	420 ,,	420 ,,	427·4 ,,	7·4

Mean difference 5·8 mμ

In Fig. 1 the averages for the crest wave-lengths of the human receptors given in column *C* of Table 1 are plotted both on an equal frequency difference basis and on an equal wave-length difference basis. It will be seen that agreement between the experimental points and a straight-line relationship is reasonably good in both cases.

With regard to Granit's micro-electrode wave-lengths, 600, 580, 540, 500, 480, 460 and 420 mμ, the same statement applies, namely, that these values

Table 2

F Granit's micro-electrode technique	*G* Granit's electric polarization method	*H* Mean values of *F* and *G*	*D* Equal frequency differences	*I* Differences between *H* and *D*
600 mμ	610 mμ	605 mμ	610·2 mμ	5·2
580 ,,	—	580 ,,	569·6 ,,	10·4
540 ,,	520 ,,	530 ,,	534·1 ,,	4·1
500 ,,	—	500 ,,	502·7 ,,	2·7
480 ,,	—	480 ,,	474·9 ,,	5·1
460 ,,	450 ,,	455 ,,	449·9 ,,	5·1
420 ,,	—	420 ,,	427·4 ,,	7·4

Mean difference, 5·7 mμ

Fig. 1

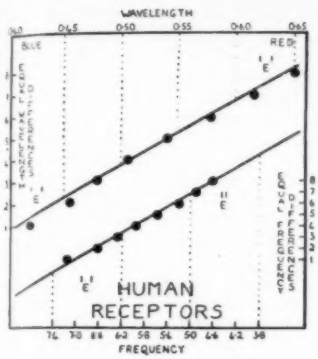


Fig. 2

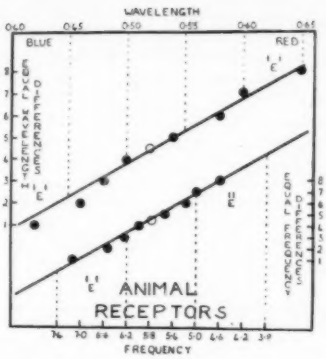


Fig. 3

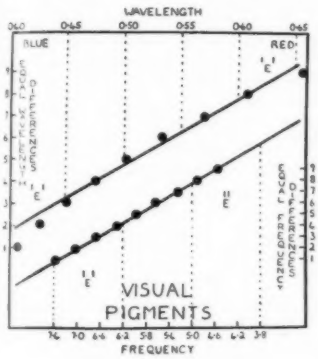
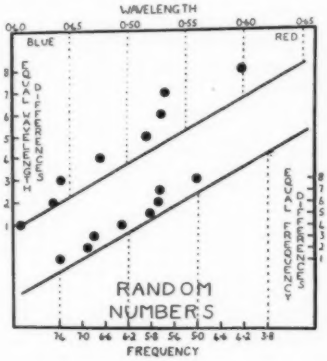


Fig. 4



are given to two significant figures only, in order to make the fact clear that the method suffers from a large experimental error so far as the determinations of crest wave-lengths are concerned; and the electric polarization method, which makes use of the micro-electrode technique, suffers in the same way. That the values given by Granit's methods are in satisfactory agreement with the same constant frequency difference series as that quoted in Table 1 above is shown in Table 2.

In Fig. 2 the average values shown in column *H* of Table 2 are shown plotted both on an equal frequency difference basis and on an equal wave-length difference basis. It will be seen that in the case of Granit's modulators also there is reasonable agreement between the experimental points and a straight-line relationship. When the wave-lengths of the known visual pigments, together with those recently identified by Dartnall, are plotted in the same way, it is found that there is reasonable agreement with a straight-line relationship, both on an equal wave-length difference basis and on an equal frequency difference basis, the agreement being better in the latter case than in the former (see Fig. 3).

Table 3

	Retinal pigments	Human receptors	Animal modulators
Retinal pigments	—	6·0 mμ	6·4 mμ
Equal frequency difference	4·6 mμ	5·8 ,,	7·4 ,,
Equal wave-length difference	10·7 ,,	4·9 ,,	8·4 ,,

In Table 3 are shown the average differences between the wave-lengths of the retinal pigments, the human receptors and the animal modulators on one hand and the retinal pigments, the equal frequency difference series and the equal wave-length difference series on the other.

What, it may be asked, are the reasons for the approximate agreement between the experimental points obtained for the retinal pigments, the human receptors and the animal modulators, and values calculated on the basis of an equal wave-length difference and on the basis of an equal frequency difference? The reasons are (*a*) that the absorption bands of the pigments and the response curves of the receptors have blunt summits, that is, that near the crests the ordinates change but little with wave-lengths; (*b*) that largely owing to this fact the methods used by Dartnall, Granit and myself do not give precise values for the crest wave-lengths; (*c*) that when wave-lengths are plotted against their respective frequencies a rectangular hyperbola is obtained, the vertical and horizontal limbs of which are nearly straight; the visible spectrum lies within one of these approximately straight portions; (*d*) that the part of the visible spectrum occupied by the receptors comprises a narrow band of wave-lengths, and in consequence the difference between the hyperbolic curve and a straight line is small. It follows that the crest wave-lengths may be in reasonable agreement with both an equal wave-length difference series and an equal frequency difference series.

If, in Table 1, the wave-lengths of Dartnall's pigments are substituted for those in column *D*, the mean difference is found to be 6·0 mμ, thus justifying the following statements. There are many types of receptor present in the human retina. The crest wave-lengths of these receptors are in good agreement with the crest wave-lengths of Dartnall's pigments[1]. It is likely that these pigments, or pigments closely resembling them, are present in human retinas for purposes of colour vision.

If, in Table 2, column *D* be replaced by the wave-lengths of Dartnall's pigments, the mean difference is found to be 6·4 mμ, thus justifying the statements: There are many receptors present in the retinas of animals. The crest wave-lengths of these receptors are in good agreement with the wave-lengths of Dartnall's pigments. It is likely that these pigments, or pigments closely resembling them, are present in animals' retinas.

It is true that twenty-five different wave-lengths have been submitted. It seems likely that each new method of obtaining the wave-lengths will produce somewhat different values. This is probably due to experimental error. But there is another possibility to be considered. In the case of hæmoglobin, different species of animals have hæmoglobins which differ

somewhat in their spectroscopic properties. It may be found that the same statement is true of the visual pigments. If these pigments resemble hæmoglobin in having protein prosthetic groups, it may be differences in the latter which bring about the changes in wave-lengths.

Here then are data obtained several years ago, by two methods on animals' retinas[2] and by two methods on humans' retinas[3], which are in agreement, within experimental error, with this modern scheme suggested by Dartnall of an equal frequency difference series. That this could not possibly happen by chance is quickly proved by applying the same criterion to random wave-lengths, because when this is done no agreement is found to occur (see Fig. 4). When, therefore, Collins and Morton write "It follows that the evidence for a constant frequency difference is quite inadequate", the weight of evidence seems to be definitely against their view.

Now, if the facts presented in this and previous communications were the only evidence available, it would still appear to be sufficient to substantiate all the above statements; but, in fact, three additional pieces of evidence are available which have not so far been mentioned.

(*a*) It is possible in other ways to determine approximately the crest wave-lengths of the human receptors. Moreover, these wave-lengths are found to be in good agreement (1) with those quoted above which are given by the fixation point and the subjective colour methods, (2) with those found in animals, (3) with the retinal pigments as determined by Dartnall, and (4) with the constant frequency difference series.

(*b*) The shapes of the response curves both of human and of animal receptors resemble one another in being single hump curves. They also resemble the wave-length – optical density curves of the retinal pigments in the same respect.

(*c*) The spans (half-height widths) of the response curves both of human and of animal receptors do not differ much from one another. Nor do they differ much from the spans of the wave-length – optical density curves of the retinal pigments. It seems likely that further research will demonstrate conformity between the spans of the receptors of different wave-length and of the corresponding pigments.

Several other physiological points might be raised with regard to Collins and Morton's letter, but three only will be referred to here.

(1) They write, "As cattle are believed to have only rods in their retinas . . .". This belief is not supported by Sir Herbert Parsons in his book on "Colour Vision"[4]. He writes: "Greeff[5] says that there are rods and cones in the retinæ of most mammals, . . . There are vertebrates possessing only rods . . . amongst mammals, hedgehog, bat, mole and nightape . . .". Thus cattle would have both rods and cones.

(2) Later on, Collins and Morton write: "as Hartridge mixes up eyes using vitamin A_1 and vitamin A_2 . . .". They are presumably referring to the fact that Dartnall worked on tench, whereas Granit worked on various animals—cats, rats, guinea pigs, snakes, frogs and tortoises—and I myself worked on human retinas, and that it seems likely that whereas some of these retinas contain vitamin A_1, others contain vitamin A_2. If that is their point, may I put the following questions to them? Is it true that the two types of vitamin A are mutually exclusive? Is it not a fact that both types have been found side by side in the liver? If they can exist side by side in the liver, why can they not do so in the retina?

(3) Collins and Morton write: "Hartridge also states that the yellow pigment . . .". Now if my letter is read again it will be found that it does not contain this statement. What will be found is: "Evidence is to be presented elsewhere for the hypothesis that the yellow pigment . . .".

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[1] Dartnall, H. J. A., *Nature*, **166**, 207 (1950).
[2] Granit, R., "Sensory Mechanisms of the Retina" (1947).
[3] Hartridge, H., *Phil. Trans.*, B, **232**, 519 (1947).
[4] Parsons, J. H., "An Introduction to the Study of Colour Vision", 14 (1924).
[5] Greeff, "Graefe-Saemisch Handb. d. ges. Augenheilkunde", **1**, 1, V (1900).

The points raised by Dr. Collins and Prof. Morton and others will be discussed in a forthcoming paper.

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TEETH OF FOSSIL PRIMATES AND MODERN APES

One of the major obstacles to the development of comparative odontology, especially so far as it bears on the problem of man's origin, has been the lack of objective criteria at the disposal of workers in the field of primate evolution. When in the early 'twenties a single fossil tooth from Nebraska, identified as that of an ape with certain human affinities, *Hesperopithecus haroldcookei*, was shown later to belong to a peccary, more than one notable anthropologist had reason to hang his head. Since then, the instructed public has been treated to a wide divergence of opinion among other specialists over the human versus ape-like qualitative features of the teeth of Peking man.

In such an impasse, the provision of material which enables less subjective comparisons to be made between the teeth of living anthropomorphous apes and contentious primate fossils is most welcome. Two joint studies by E. H. Ashton and Prof. S. Zuckerman, "Some Quantitative Dental Characteristics of the Chimpanzee, Gorilla and Orang-Outang" and "Some Quantitative Dental Characters of Fossil Anthropoids"*, in turn furnish, according to a rigorously defined technique of measurement, the main absolute and relative dimensions of larger samples of the teeth of modern great apes than have hitherto been available, and then compare statistically the results obtained with the values published by the describers of some extinct primate forms.

Owing to the dubious validity of the sex that has been assigned (all too often with alarming unconcern) to individual, and particularly young, fossil specimens, their dental characters are in each case compared with those of both male and female contem-

* *Phil. Trans. Roy. Soc.*, B, **234**: No. 616, "Some Quantitative Dental Characteristics of the Chimpanzee, Gorilla and Orang-Outang" (pp. 471–484, 5*s.*); No. 617, "Some Quantitative Dental Characters of Fossil Anthropoids" (pp. 484–520, 9*s.*). By E. H. Ashton and S. Zuckerman. (London: Cambridge University Press, 950.)

porary anthropomorphs; and it may be said at once that, in the light of the new data, several previous assertions minimizing the metrical resemblances between the teeth of the fossils and living apes will need modification. No far-reaching claims to have demonstrated more than that which arises of its own accord from the procedure they employ are advanced by the authors; and their reserved attitude stands in sharp contrast to many less-cautious pronouncements, on the basis of dentition, concerning the evolutionary status of the Australopithecines from South Africa and the *Proconsul*-group from Kenya, to say nothing of the teeth recently found in Java and southern China and attributed to Hominids, and the Piltdown I molars.

Despite the lead given by Simpson and others in the United States, the adoption of statistical methods on the part of palæontologists elsewhere is tardy; and if, as seems probable, one of the effects of the studies described is to induce in them a change of attitude, this can be only for the good. The fulfilment of the authors' promise of a further paper dealing with analogous measurements of teeth of the various races of mankind will be awaited with interest.

HAWAIIAN HONEYCREEPERS

THE Hawaiian Islands are very isolated oceanic islands of volcanic origin. Their great elevation and their position just within the tropical zone athwart the north-east trade winds assure much local variation in climate and rainfall. The climate is tropical and the rainfall in the mountains heavy, producing a luxuriant, though botanically rather undiversified, rain forest wherein the vast majority of the Hawaiian honeycreepers (Drepaniidæ) find their home. These honeycreepers are often cited in general works on evolution as striking examples of adaptive radiation; and, in a recent *Bulletin of the American Museum of Natural History* (**95**, No. 4; 1950), Dean Amadon examines existing knowledge in the light of his own observations and assesses the evolutionary significance of these Pacific birds.

The family Drepaniidæ is divisible into two well-defined sub-families; these contain eighteen 'zoogeographical' species, and about twenty-two species in all when geographically representative species are counted separately.

Coefficients of variation for these birds seem to be of the same order of magnitude as for other birds. This is true even of the bill, which has undergone considerable recent adaptive change in several of the genera. As in most birds, the individual variability in bill-length is greater than that in tail-length, and the latter slightly exceeds that in wing-length. No effect on variability of small population size or of specialization could be demonstrated; but the available measurements were not extensive or precise enough to reveal slight differences. Males are larger than females in the Drepaniidæ, sometimes rather markedly so. Sexual difference in bill size is, in some species, relatively greater than that in general size. There is some reason for believing that this is sometimes the result of non-selective positive allometry, especially in the genus *Hemignathus*. Variations in size and proportions among the races, species, and genera of the family seem to be adaptive; others may or may not be.

Immature drepaniids are rather dull in colour, adult females usually a little brighter, and adult males often brilliant red or orange. In the sub-family, the Drepaniinæ, adult males and females are both brilliant red in several species. Degree of sexual dimorphism in colour occasionally varies abruptly from species to species in a genus or even from race to race. Individual variation in colour is usually slight; but in one or two forms an orange or yellowish tone may be present or absent. Geographical variation in colour, while occasionally striking, is no more so than in other insular song birds. Red plumage is most frequent in the less specialized members of both sub-families, suggesting that it was characteristic of the earliest drepaniids. In the Drepaniinæ a trend towards black plumage culminates in the entirely black *Drepanis funerea*.

The Hawaiian honeycreepers are notable for the adaptive radiation which permits them to utilize a variety of foods: nectar, insects (secured in many ways), fruits and seeds. In the Drepaniinæ, four of the five genera are primarily adapted to feeding upon nectar and small insects from flowers. The fifth genus, *Ciridops*, was evidently frugivorous (its only species became extinct very quickly). Some of the species of the other sub-family are adapted for digging insects from wood; others have very heavy, finch-like bills suitable for crushing seeds and fruit.

The song and call notes of the two sub-families of the Drepaniidæ are quite unlike. Most of the species nest during the spring months and build an open nest of rootlets, moss and similar material. It is placed among the twigs of bushes or trees at widely varying elevations. The eggs vary from two to four in number and are spotted. Apparently only one brood is raised, though more information is needed on this point. All the Hawaiian honeycreepers fly well; but there is slight evidence of incipient reduction of the wing in the two forms native to the little atoll of Laysan.

The Drepaniidæ have a number of known parasites and are subject to various diseases, including bumble-foot, or bird pox, and probably avian malaria. Some or all of these diseases were brought in by introduced birds and may well be the most important factor in the decline and extinction of many of these birds. Other factors adverse to the endemic avifauna are destruction of the forest for agriculture or by live-stock, competition with introduced birds, and predation by such introduced mammals as the mongoose, cat and three species of rats.

The small size of many of the insular populations probably tends to limit genetic variability and capacity for adaptive response to changing conditions. With the arrival of the Hawaiians and later of white men on the islands, the environment deteriorated, and widespread extinction of the more vulnerable components of the avifauna quickly ensued.

The supposed phylogeny of the genera of the Drepaniidæ shows that the most primitive genus in each sub-family contains small, arboreal forms with moderately decurved bills and tubular tongues. They feed chiefly on nectar and insects. All the more specialized insect-, nectar-, fruit- and seed-eating genera have evolved from such forms. Some species that no longer eat nectar still have a tubular, nectar-sucking tongue like that of the more generalized drepaniids. To suggest derivation of the family from finches or heavy-billed tanagers runs counter to this evidence and to some anatomical characters.

In the Drepaniidæ, as in other birds, the development of species involves gradual differentiation of geographically isolated populations. The isolation

has been on different islands, but with much secondary overlap of species so that as many as fifteen occurred on a single island (Hawaii). In some species inter-island stragglers are so frequent that differentiation does not occur or is held at the racial level. The more isolated islands receive fewer stragglers, and as a result endemism is very pronounced. The larger islands have a more varied ecology than do the smaller ones. This is reflected in a richer avifauna, apparently because many species are able to survive on the larger islands by utilizing ecological niches absent on the smaller ones. Birds straggle from island to island so frequently that the relative ages of the islands of the Hawaiian group are not reflected in the composition of the bird life. In this, birds differ from more sedentary groups such as molluscs.

Adaptive radiation—the occurrence of a number of very different ecological types within a taxonomic group—is usually best illustrated by families or orders; but in the Drepaniidæ it occurs within the limits of a family.

SCIENCE TECHNOLOGISTS ASSOCIATION

FOR many years technicians in science laboratories in educational institutions and industry throughout Great Britain have been conscious of the need of a professional organization to cater for that large body of laboratory technicians not covered by an association in the way, for example, medical laboratory technicians are covered by the Institute of Medical Laboratory Technology, and to provide schemes of training with the view of certification and registration at a professional level.

Early in 1948 the Science Technologists Association was formed. The training scheme as approved by the Association is a five-year course covering so far as practicable all branches of science: three years of study are required for the certificate and a further two years for the diploma, all instruction being given by experienced technicians and the emphasis being placed on the practical side of the technician's work. It may be noted that the Association is at present providing the instruction for the City and Guilds course of laboratory technician work which is now running at the Paddington Technical Institute. The honorary general secretary (Department of Chemistry, Imperial College of Science and Technology, London, S.W.7) will provide further details and syllabuses to those interested.

The president of the Association is Prof. C. H. O'Donoghue, professor of zoology in the University of Reading, and there are eight vice-presidents, all of them men of science. The president and vice-presidents, together with eighteen elected technicians, form the Council of the Association. Fourteen of the technicians also form a General Purposes Committee which acts as the executive of the Association.

There are at present four branches: London, Edinburgh, Glasgow and Cardiff. All are active and organize local activities, lectures, visits, etc., and, when possible, hold classes based on Association syllabuses. The branch at Edinburgh has been especially successful in this respect, and the classes are now running in their second year. A *Bulletin* is published at regular intervals and is proving a useful means of keeping members informed of activities. A list of vacant situations is included, and the editor will be pleased to advertise any vacancies sent to him.

The Association has expanded rapidly, new members being enrolled steadily. Potential membership is very large, and the immediate aim is to build up a substantial membership to give the Association an authority in the shortest possible time. The ultimate objective, namely, the formation of an Institute with a registered address and paid officers, although still some way off, is becoming nearer. The immediate benefit of the Science Technologists Association to established technicians may not be very apparent; but it can claim to being a body which belongs to technicians and provides the opportunity for them to achieve professional status and recognition of their undoubted abilities and place in organized science.

MATHEMATICAL ASSOCIATION

ANNUAL MEETING AT BRISTOL

THE annual meeting for 1951 of the Mathematical Association was held at Bristol during March 28–31, under the presidency of Prof. H. R. Hassé, professor emeritus of mathematics in the University of Bristol. Members of the Association were welcomed by the vice-chancellor of the University, Sir Philip Morris, at a reception held in Wills Hall on the evening of the first day of the meeting.

On the morning of March 29, Prof. Hassé gave his presidential address on "My Fifty Years of Mathematics", in which he traced the changes in the range and character of the teaching of mathematics to university students in the period 1900–50. Prof. Hassé considered the consequences of the abolition of the order of merit in the Mathematical Tripos at Cambridge, of the emphasis on rigorous demonstration in analysis given by Hardy and Bromwich in their books, and of the growth of a lively geometrical school under H. F. Baker; and he illustrated all this by noting the tendency to replace geometrical by analytical methods in applied mathematics, the increased use of vector methods, the destruction of the old sharp distinction between pure and applied mathematics, and the increased importance of an algebraic basis for geometry.

The Association's Teaching Committee will shortly be engaged on a revision of its report on the teaching of algebra. To direct the attention of teachers to this task, Mr. W. J. Langford (Battersea Grammar School) spoke on the teaching of algebra in schools, particularly condemning over-elaboration of manipulative technique at the expense of clear grasp of methods.

On March 30, the first item was a symposium on Modern School work, organized by Miss L. D. Adams (H.M. Inspector of Schools). Aspects of Modern School teaching were explained by three teachers from Bristol schools, and a large and varied display of work done by children in Modern Schools was exhibited. Much of this work came from Bristol schools; but items from all parts of Great Britain had been obtained and were on show. An inspection of this work gave the impression that the very considerable difficulties which confront the teacher of mathematics in the Modern School are partially diminished by the comparative freedom under which the work is done.

Prof. C. F. Powell (University of Bristol) then gave a lecture on "Cosmic Radiation", a brilliantly

lucid account of the nature of the particles among the primary cosmic radiation, and the processes occurring in the atmosphere as a result of collisions of these particles with nuclei, illustrated by films and slides.

On the afternoon of the same day the Association discussed the recently published report of its Teaching Committee on the teaching of trigonometry. Mr. C. O. Tuckey (formerly of Charterhouse School) explained the origins of the report, mentioning in particular the discussion of the vexed question as to whether it is best to begin with the sine, the cosine or the tangent, the examination of the merits of various proofs of the fundamental addition-formulæ, and the chapter containing a concise survey of vectors and complex numbers. Mr. G. L. Parsons (Merchant Taylors' School) described the attempt made in the report to strengthen the links between geometry and trigonometry, though he regretted that the report had not been bold enough to advocate complete fusion of these two topics.

The last paper of the day was given by Prof. H. A. Heilbron (University of Bristol), in which he spoke of the discoveries of the past fifty years, chiefly made by Prof. O. Neugebauer, which have revealed the astonishing flowering of Babylonian mathematics in the era 1950–1600 B.C.

The final day of the meeting was devoted to a discussion on "Scholarship Syllabuses in the General Certificate of Education and in University Examinations", opened by Mr. P. C. Unwin (Clifton College), Mr. H. E. Parr (Whitgift School, Croydon), Mr. F. J. Tongue (Kingswood School), and Dr. W. L. Ferrar (Hertford College, Oxford). These speakers, and those who took part in the open discussion, agreed that much further co-operation between the schools and the universities is needed, but there was no general agreement on the best form of machinery for obtaining such increased co-operation. On the question of syllabuses, most teachers felt that some kind of guidance is desirable, but detailed syllabuses were generally opposed; a general list of topics, with an indication of those domains not considered suitable as examination subjects at this level, would meet the needs of the teacher. With the inevitable extension of the field of examination topics, a possible tendency to replace searching questions on elementary subjects by easy questions on advanced subjects was deprecated at the university scholarship stage.

The president of the Association for 1951 is Dr. M. L. Cartwright, Mistress of Girton College, Cambridge.

FORESTRY IN THE FEDERATION OF MALAYA

ANNUAL REPORT FOR 1949 OF THE FEDERAL FOREST ADMINISTRATION

FROM the news in the Press it might be thought that ordinary administration and, more especially perhaps, forestry administration would be more or less at a standstill in Malaya. The annual report for 1949 of the Federal Forest Administration in the Federation of Malaya*, by J. P. Edwards, acting director of forestry, shows the reverse, particularly in the professional and research sides of the work. It is true that the report states that, in connexion with saw milling, "Bandit activity has also caused the sawmills much difficulty. One was burnt down, several more have closed down to avoid being forced to provide supplies to the bandits, others have had lorries destroyed and many find difficulty in persuading their logging gangs to remain at work. The Police, too, are often obliged to clear the forest of loggers so that they are not mistaken for bandits during security operations. In spite of this millers have shown great determination to keep producing and develop their mills. Eleven new mills were planned and five others increased their plant."

For the first time since 1940 all research posts, with the exception of the chief research officer, were filled. Very considerable work is being undertaken in sylvicultural research, a Sylvicultural Research Committee being appointed. The function of the Committee is to advise on ecological, botanical, sylvicultural, and mensuration research and, under the general direction of the director of forestry, to prepare long- and short-term research programmes. The Committee has correctly laid down the aim of sylvicultural research as: "The aim of silvicultural research is the acquisition and dissemination of knowledge which will enable the best use to be made of forest land in accordance with the objects of management. Where production of timber is the main object, its aim will be to achieve the optimum sustained yield."

The remarks on natural regeneration show a true progress by the Department in spite of all the vicissitudes it has gone through during the past decade and more. "Silvicultural technique must, of necessity, be adapted to changes in exploitation methods. Selective logging by hand-sawyers using buffalo extraction has given place, during the last two decades, to sawmills utilizing a wide variety of species and extraction by means of temporary lorry roads. The removal of the mature crop in two or more successive fellings is not suited to these more modern methods where extraction costs are heavy and it has become economically necessary to remove all utilizable trees in one operation. This raises a number of silvicultural problems including the determination of the minimum seedling frequency and distribution which can be relied upon to produce a full crop at maturity, and the type of tending operations necessary to secure the rapid development of the crop. These and allied problems were under active consideration during the year but field work has been hampered by the emergency."

There is a beautiful photograph in the report of part of a plantation of Kapur (*Dryobalanops aromatica*). Planted at the Forest Research Institute in 1927 at 12 ft. × 12 ft. apart, it was thinned in 1936 and again in 1949. After the latter thinning, there were left approximately 100 stems per acre, averaging 90 ft. in height with an average diameter of 10 in.

The report of the Federal Forest Administration contains also separate reports for each of the States of the Federation.

Besides the above, other interesting publications have recently been issued. These include two Trade Leaflets of the Forest Service: No. 13, which deals with two Malayan timbers, jeluton and nyatoh, both in a popular fashion; and No. 14, which consists of a diagram illustrating the use of Malayan timbers for building construction. Two reprints from the *Malayan Forester*, Nos. 77 and 78, deal with, respectively, the elements of Malayan sylviculture during 1950, written by the research sylviculturist, and logging by tractors.

* Report on Federal Forest Administration in the Federation of Malaya for the Year 1949. By J. P. Edwards. Pp. 68+4 pl. (Kuala Lumpur: Government Printer, 1950.) 2 Malayan dollars or 4*s*. 8*d*.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

The Clock Paradox in Relativity Theory

The relativistic phenomenon of 'time dilatation' is usually taken as showing that, if R,M are two observers initially at rest on, say, the earth, and if M makes a journey and rejoins R who remains at rest, then the duration of M's journey is shorter in M's reckoning than in R's. However, it can then be pointed out that we are apparently concerned only with the relative motion of R,M and that consequently M could regard himself as remaining at rest and R as performing a journey. In that case, the duration of the journey should apparently be shorter in R's reckoning. Since both conclusions cannot be correct, we have a paradox.

This so-called 'clock paradox' has been well known for many years, and is usually regarded as resolvable by general relativity theory[1]. Nevertheless, it continues to attract attention[2–4]. So far as I am aware, it has never been made quite clear that there really is no paradox. Though we have only to do with the relative motion, that of M relative to R is *not* the same as the motion of R relative to M.

We consider the following particular example which, so far as the requirements of the problem are concerned, can be treated completely by the special theory of relativity. It is a slightly modified form of the standard example.

The observers R,M are initially at rest in an inertial frame F; R remains at rest; M moves directly away from R and travels for time T with uniform speed V in R's reckoning; M then comes to rest in F, remains at rest for time t, then returns to R, with the exact reverse of his outward motion. The times during which M's speed is changing at the start and finish of his outward and return journeys, and the time t, are given and are independent of T. Whatever these times may be, we take T so great that they are negligible compared with T. Then the following statements can be made with negligible errors.

At the event of M's completing the part of his outward journey performed with speed V, observer R plots M as at a distance $X(=VT)$ from himself. (We say 'plot' instead of 'see' to avoid complications about times of travel of light in the process of seeing.) Owing to the Lorentz contraction, M at the same event plots R as at distance αX from himself, when $\alpha = (1 - V^2/c^2)^{1/2}$. During the interval t when R,M are both at rest in F, they must each plot the other as at distance X. But as soon as M has again acquired uniform speed V, this time towards R, he again plots R as at distance αX.

R's account of M's journey relative to himself is, still neglecting quantities small compared with X and T: M moves out and back through distance X at speed V; total time $2T$. On the other hand, M's account of R's journey relative to himself is: R moves out through distance αX at speed V, then R 'cheats' by rushing out to distance X and back again to distance αX in negligible time, and finally completes his return at speed V; total time $2\alpha T$. This is less than $2T$ and is the usual result.

It does not matter which observer regards himself as at rest, and neither need know anything about inertial frames. All that is necessary is for an umpire to supply them with standard clocks and scales and to tell each to record a plot of the other's apparent motion. The whole point is that these plots will not be the same. There will be an unambiguous difference between the results which will involve no paradox.

This particular example is treated by special relativity theory; but it is sufficient to obtain one example in which two observers give different descriptions of their relative motion in order to assert that in general they will not give the same description.

It is easy to construct examples where the observers *are* symmetrically related. In all such cases, the symmetry alone suffices to ensure that they will assign the same time for the relative journey. With due consideration of the provision of equivalent clocks, this is the conclusion reached by Milne and Whitrow[3] using the technique of kinematic relativity. However, they state no conclusion regarding the standard example. Jellinek[4] recognizes that the asymmetry between R and M is significant in this example, but he assigns the asymmetry to "clock-systems" in an argument which I have failed to understand.

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Origin of Atmospheric Argon and the Radioactive Decay Constants of Potassium-40

In a previous communication[1], it was pointed out that E. Bleuler's and M. Gabriel's[2] estimates of the total half-life and K-capture to β-ray emission branching ratio were probably too high, since they led to an excessive quantity of argon-40 being produced by the surface materials of the earth during geological time. The more recent determinations of the radioactive decay constants of potassium-40 seem to have amply confirmed this view: in fact, if they are correct, the present difficulty is to explain the origin of argon-40 in the atmosphere.

Harrison Brown[3] considers that argon-36 is cosmically the most abundant isotope of argon, and concludes[4] from the terrestrial and cosmical abundances of the noble gases that the earth in its early history was so hot that it was unable to retain any atmosphere. The existing atmosphere is considered to be of secondary origin, being derived from gases emitted from the crust of the earth during its solidification. Atmospheric argon consists of 99·6 per cent of argon-40 and, consequently, the evidence for it having been produced by the radioactive decay of potassium-40 in the earth's crust during geological time is very strong.

If we take the potassium content of the earth's crust as 2·6 per cent and that one gram of natural potassium contains $1{\cdot}2 \times 10^{-4}$ gm. of potassium-40, we can easily calculate the depth of the surface layer required to produce the present amount of atmospheric argon-40 in, say, 3×10^9 yr., when the decay constants of potassium-40 are known. It is assumed

Authority	λ_β	Branching ratio	Depth of layer
Ahrens and Evans[5]	$6{\cdot}5 \times 10^{-10}$ per yr.	1·38	0·26 km.
Sawyer and Wiedenbeck[6]	$4{\cdot}9 \times 10^{-10}$ per yr.	0·136	29·9 km.
T. Graf[7]	$4{\cdot}7 \times 10^{-10}$ per yr.	0·67	4·6 km.

Assumed density of layer = 2·7 gm./c.c.

that all the argon-40 generated in this layer has escaped into the atmosphere. In the accompanying table we give some of the more recent determinations of the decay constants of potassium-40, and the depth of the layer required. λ_β refers to the beta-ray disintegration of potassium-40.

According to Goldschmidt, the upper limit for the amount of igneous rocks denuded during geological time is 160 kgm. per cm.^{2} of the earth's surface, or a layer about 0·6 km. deep. Thus, Ahrens and Evans's figures could easily explain the production of atmospheric argon; but it may seem difficult to believe that argon could have escaped from a layer 30 km. deep, as Sawyer and Wiedenbeck's figures require. T. Graf[8] has already pointed out this difficulty.

Both Graf's and also Sawyer and Wiedenbeck's results are based on direct measurements of the decay constants of potassium-40. Ahrens and Evans deduce their values from the calcium-40 to potassium-40 ratio for lepidolites of estimated age $2{\cdot}1 \times 10^9$ yr., and the measured value of λ_β for potassium-40. They, and Graf, conclude that most capture processes in potassium-40 are not followed by gamma-ray emission; but Sawyer and Wiedenbeck's experiments, in which they used an enriched potassium-40 source, seem to disprove this hypothesis. Furthermore, the branching ratio of potassium-40 can be investigated by determining the amount of radiogenetic argon-40 in old potassium minerals. Suess[9], Aldrich and Nier[10], and Hess, Brown, Patterson and Inghram[11] have used this method, and all their results lead to a low value of the branching ratio, in agreement with Sawyer and Wiedenbeck. On the whole, the bulk of the existing evidence seems to point to Sawyer and Wiedenbeck's values being correct, which leads to the geophysical difficulty of explaining the origin of atmospheric argon.

We have attempted to explain this discrepancy by assuming that potassium-40 is not a single element capable of disintegrating in two different ways, but consists of two non-genetically connected nuclear isomers one of which decays by K-capture and the other by beta-ray emission. Since the percentage composition of existing potassium-40 would be unknown on this theory, it is obviously possible to reconcile Sawyer and Wiedenbeck's results with the amount of argon-40 in the atmosphere, assuming that the argon is derived from a layer of about 0·6 km. deep. When this is done, however, the amount of argon-40 which should be present in old potassium minerals far exceeds the experimental results of the authors already quoted, and on this ground the hypothesis should probably be rejected. It is also possible, taking Sawyer and Wiedenbeck's results and Ahrens and Evans's calcium-40 to potassium-40 ratio for ancient lepidolite, to produce a scheme which agrees quite well with the measured argon-40 contents for old minerals of other investigators. Unfortunately, when this is done, it turns out that the depth of the layer required to produce atmospheric argon is about 70 km. Thus on all grounds the isomer hypothesis seems unacceptable.

We are thus forced to conclude that either atmospheric argon is not derived from potassium-40 in the crust, or that if the low branching ratio of potassium-40 is correct, which seems probable, argon can escape from a considerable depth in the crust. Any theory of the earth's structure, such as that of Prof. A. Holmes, which postulates slow convection currents in the substratum, would give a plausible explanation of this phenomenon, since it might mean that a small percentage of the argon generated in quite a considerable fraction of the earth's volume could escape through volcanoes, etc., during geological time.

A more detailed discussion of these results will be published elsewhere.

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Dislocations in Real Crystals

The concept of 'dislocations' has been used to account for the 'slip' process of plastic deformation of crystals. Following Burgers[1] and Shockley[2], the most convenient way of defining a dislocation is the following: In the crystal lattice represented in cross-section in Fig. 1, let the unit distance in the x direction be a, and that in the y direction, b. The unit in the z direction, not shown in this diagram, is c. Starting at the point P, let the following 'moves' be made in sequence: (1) n units in the x direction; (2) m units in the y direction; (3) p units in the z direction; (4) n units in the $-x$ direction; (5) m units in the $-y$ direction; and (6) p units in the $-z$ direction. In a region of perfect crystal, the point reached as a result of these moves will coincide with the starting point P. If, however, the region encompassed by the path so described contains a dislocation, an extra step will be required to close the circuit. The extra step is the Burgers' vector S of the dislocation.

It is of interest to compare the shear-strain energies of the variously oriented dislocations that can be

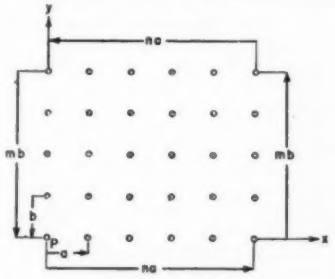

Fig.

regarded as geometrically possible in a given crystal lattice. The lattice distortion corresponding to a dislocation can be expressed in the following way. Consider the loop $PQRTUP$ in Fig. 2. If n is reduced to $n-1$, the loop becomes $PQ'R'TUP$, and if m is reduced to $m-1$, it becomes $PQ'R''T'UP$. This process can be continued until the loop PQ_nU remains. The tangent of the angle β in this triangle represents the shear-strain in the lattice resulting from the existence of the dislocation. The process of creating a dislocation can be regarded as consisting of two stages, of which the first is the creation of the primitive loop PQ_nU, and the second is the insertion of extra atoms if necessary and the readjustments of the positions of the atoms to minimize the energy of the distorted array. The amount of the initial strain will control the shear-strain energy that is retained. It follows that in an actual crystal lattice the dislocations that are the most likely to exist will be those which have the smallest possible values of the angle β.

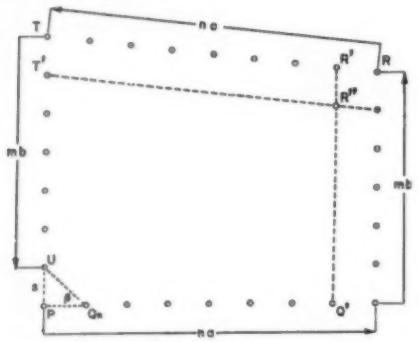

Fig. 2

A dislocation is defined by its Burgers' vector. In order to specify the orientation of the dislocation with respect to the crystal lattice, it is necessary to select a plane that contains the Burgers' vector. Among the set of possible planes for one fixed Burgers' vector, the one corresponding to the minimum value of β is most likely to exist in a real crystal.

The distance UP is the interatomic spacing in the direction of the Burgers' vector, and PQ_n is the interplanar spacing of the planes parallel to the selected plane. The appropriate values of β have been calculated for all the more probable dislocations in the face-centred cubic, body-centred cubic, close-packed hexagonal and body-centred tetragonal lattices.

In all these cases, the Burgers' vector and selected plane which correspond to the smallest value of β are identical with the observed slip direction and slip plane respectively[2]. In cases where n alternative slip systems are reported, they correspond to the lowest values of β.

It is concluded that the observed slip systems can be accounted for in terms of the dislocations of lowest energy that are crystallographically possible; it cannot be determined, without other energy considerations, whether edge-type or screw-type dislocations are responsible, since the angle β is the same for both types for a given slip system. It is suggested that the foregoing simple and approximate analysis of the relative energies of different dislocations explains why slip always occurs in closely packed directions and on densely packed planes, and that it is possible to predict the slip systems that should be operative in crystals with other lattices.

If the dislocations postulated by Frank[4] as a necessity for crystal growth are oriented in the manner predicted above, it should be possible to predict the crystallographic direction of preferred growth from the melt, including dendritic growth. The [100] growth of dendrites in lead has been explained in this way.

A detailed development of the theory outlined above will be published elsewhere.

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Q-Values of the (p,α) Reactions in Lithium-6, Lithium-7 and Nitrogen-15, and the $B\rho$ Values of Thorium C' and Polonium Alpha-Particles

Accurate values for the energy balance in nuclear reactions are important for establishing the scale of nuclear mass as well as providing confirmation of the Einstein mass–energy relation. During the past two and a half years, we have determined the Q-values for ^{7}Li, ^{6}Li and ^{15}N (p,α) reactions, as well as the $B\rho$ for the α-particles from thorium C′ and polonium. A uniform-field magnetic spectrometer of the Cockcroft[1] design has been used in conjunction with a high-voltage accelerator. The magnetic field around the semi-circular particle-trajectories has been measured by determining the nuclear resonance-frequency of protons in a small sample of water, and converted to absolute values by using the value of the proton gyromagnetic ratio due to Thomas, Driscoll and Hipple[2]. The diameter of the particle-trajectories has been measured absolutely and values of $B\rho$ (and hence energies) have been derived directly in terms of the spectrometer geometry and the above measurements. Reactions have been studied for 90° emission from a beam of 400-keV. protons, and the high-tension voltmeter scale calibrated by measuring the momentum of elastically scattered protons.

Two of us have treated the experimental data independently, and the following results represent agreed figures for the values and limits of error. In no case did our nominal figures differ by more than 30 per cent of the assigned limits of error. In reducing the results, we have used the isotopic masses recommended for adoption by Bainbridge[3] and the values of other fundamental constants recommended by Dumond and Cohen[4].

(i) Thorium C′ α-particles, main group: $B\rho = 427{\cdot}05 \pm 0{\cdot}10$ kilogauss cm. (13 results).

(ii) Polonium α-particles: $B\rho = 331{\cdot}74 \pm 0{\cdot}10$ kilogauss cm. (6 results).

(iii) ^{6}Li (p,α) ^{3}He: $Q = 4{\cdot}015 \pm 0{\cdot}006$ MeV. (6 results for each of the ^{3}He and ^{4}He particles).

(iv) ^{7}Li (p,α) ^{4}He: $Q = 17{\cdot}325 \pm 0{\cdot}013$ MeV. (8 results).

(v) ^{15}N (p,α) ^{12}C: $Q = 4{\cdot}960 \pm 0{\cdot}006$ MeV. (5 results).

(vi) Thorium C$-\alpha_0$: $B\rho = 354{\cdot}22$ kilogauss cm. (1 result).

(vii) Thorium C$-\alpha_1$: $B\rho = 355{\cdot}50$ kilogauss cm. (1 result).

We are not prepared to assign limits of error to the last two figures, since they are based on only one measurement, although we believe that the limits are of the same order as those given in (i) and (ii) above.

Work is still in progress, and details of the experimental procedure, analysis of the shapes of the spectrometer line for various distributions of momentum and discussion of the sources of error, etc., will be submitted for publication elsewhere.

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Slow Neutron Cross-section of Bromine

Since the publication of our communication on the slow neutron cross-sections of molybdenum and bromine (*Nature*, **166**, 825; 1950) further analysis of the bromine sample has revealed the presence of some impurities (principally chlorine). After applying the small corrections, the experimental points are best fitted by the equation:

$$\sigma_t = (5{\cdot}9 \pm 0{\cdot}2) + \frac{1{\cdot}03 \pm 0{\cdot}04}{\sqrt{E}} \text{ barns.}$$

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Heterochromatic Photometry using Rotating Filters and a Colour Wedge

Most methods of heterochromatic photometry currently employed are based on dual optical systems, consisting of two beams of light which pass through appropriate filters and fall on two photo-cells. We have developed a method which uses a single beam of light and which appears to have certain advantages over these dual systems. The method has been developed primarily for internal standard flame photometry; but the principles may be of interest to workers in other fields. We wished to compare accurately the intensity of sodium radiation emitted from a flame with the intensity of lithium radiation emitted simultaneously. The wave-lengths involved were approximately 5900 A. and 6700 A.

The light from the flame is collected by a condensing lens and passed through stationary filters which absorb light of wave-length longer than that emitted by lithium and shorter than that emitted by sodium. It then falls on a colour wedge made of glass and containing chrome alum in water solution. This solution absorbs light of wave-length 5900 A. strongly. By adjusting the position of the wedge the thickness of the solution through which the light is passed can be changed. The wedge is mounted on a metre stick so that its position in relation to an arbitrary zero point can be measured. The light falls next on rotating filters which consist of semicircular pieces of gelatin film (Wratten 34 *A* and 59 *A* are suitable) cemented between 'Perspex' disks. The disks are rotated at 9 cycles per second. Finally, the light falls on the photo-cell, which is of the vacuum type and has a cæsium – silver oxide cathode. The photo-cell is connected to a resistance-capacity coupled amplifier the output of which is rectified and recorded on a meter. Measurement is made by moving the colour wedge until a null point is obtained; this position is linearly related to the logarithm of the ratio of light intensity, as may be shown by the following calculation.

Let I_{Na} be the intensity of sodium light falling on the wedge, I_{Li} that of lithium light, T_{Na} the transmission of the wedge for sodium light at the null point, expressed as a fraction, and T_{Li} that for lithium light. Then the intensity of light falling on the rotating filters will be: $I_{Na}T_{Na} + I_{Li}T_{Li}$. If a and b are the respective transmissions of one of the rotating filters for sodium light and lithium light, then when this filter is in place the intensity of light falling on the photo-cell will be $aI_{Na}T_{Na} + bI_{Li}T_{Li}$.

If p and q are factors depending on the sensitivity of the photo-cell to sodium light and to lithium light respectively; and if, furthermore, the currents due to light at the two wave-lengths are additive, then the current produced by the photo-cell will be $paI_{Na}T_{Na} + qbI_{Li}T_{Li}$. When the other of the rotating filters has been moved into position, the current will be $pcI_{Na}T_{Na} + qdI_{Li}T_{Li}$, where c and d correspond to a and b.

At the null point these currents are equal, that is:

$$paI_{Na}T_{Na} + qbI_{Li}T_{Li} = pcI_{Na}T_{Na} + qdI_{Li}T_{Li},$$

$$\text{or} \quad \frac{I_{Na}}{I_{Li}} = \frac{q}{p}\left(\frac{d-b}{a-c}\right)\frac{T_{Li}}{T_{Na}}. \qquad (1)$$

By definition, $T_{Li} = 1/10^{D_{Li}}$ and $T_{Na} = 1/10^{D_{Na}}$, where D_{Li} and D_{Na} are the optical densities of the wedge for lithium light and sodium light. It follows that:

$$\frac{T_{Li}}{T_{Na}} = \frac{10^{D_{Na}}}{10^{D_{Li}}} = 10^{(D_{Na}-D_{Li})}.$$

Now $D_{Li} = kD_{Na}$, where k is a characteristic of the solution in the wedge; hence

$$\frac{T_{Li}}{T_{Na}} = 10^{D_{Na}(1-k)}. \qquad (2)$$

Further, since the optical density of the wedge is proportional to the thickness of the solution through which the light is passed, and since, by simple geometry, the thickness of the solution is related linearly to R, the measurement of the position of the wedge, it follows that:

$$D_{Na} = mR + n,$$

where m and n are constants. Substituting this expression for D_{Na} in equation 2:

$$\frac{T_{Li}}{T_{Na}} = 10^{(mR+n)(1-k)}. \qquad (3)$$

From equations 1 and 3:

$$\frac{I_{Na}}{I_{Li}} = \frac{q}{p}\left(\frac{d-b}{a-c}\right)10^{(mR+n)(1-k)}$$

or, $\log \frac{I_{Na}}{I_{Li}} = (mR + n)(1 - k) + \log \frac{q}{p}\left(\frac{d-b}{a-c}\right)$. (4)

Since a, b, c, d, m, n, p, and q are constants, this equation may be written as

$$\log \frac{I_{Na}}{I_{Li}} = sR + t, \qquad (5)$$

where s and t are fresh constants.

It is evident from equations 4 and 5 that the slope of the calibration curve ($\log(I_{Na}/I_{Li})$ versus R) depends solely on properties of the colour wedge. The smallest value of I_{Na}/I_{Li} for which a null point can, theoretically, be obtained is found by putting $T_{Li} = T_{Na} = 1$ in equation 1, and is equal to $\frac{q}{p}\left(\frac{d-b}{a-c}\right)$. This value depends on properties of the photo-cell and of the rotating filters, but does not depend on properties of the colour wedge. In practice, however, the null point must be straddled by taking readings on either side; further, the extreme tip of the wedge is not usable, so that the smallest measurable value of the light intensity ratio is somewhat higher than this calculation would suggest.

This system of photometry makes minimal demands on the properties of the components. Thus allowance has been made in the calculation for the fact that the colour wedge may absorb lithium light to some extent; it is therefore unnecessary to search for a solution which absorbs sodium light but transmits lithium light without attenuation. Further, the rotating filters do not have to effect a perfect separation of the two wave-lengths; indeed, the system will work so long as one of the rotating filters transmits a greater fraction of the sodium light and a smaller fraction of the lithium light than the other. The measurements are independent of fluctuations of amplifier gain, and of non-linearity in the amplifier; they depend solely on properties of components of the optical system, which are unlikely to change from day to day. It is possible to work at low intensities of light since the amplifier does not have to deal with direct current, and it is practicable, therefore, to use several stages of amplification. In addition, it is probable that temperature and fatigue effects are minimized since the comparison is effected on a single photosensitive surface.

A separate publication by one of us (E. G. W.) will deal with the practical application of this method to flame photometry.

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Variations in the Length of the Day

The article by R. I. B. Cooper[1] describes, *inter alia*, an investigation made by us to determine the effect of change in the ocean's moment of inertia, due to seasonal changes in sea-level, upon the periodic fluctuation in the length of the day.

In this investigation, from a study of the anomalies about mean sea-level, the increase of the ocean's moment of inertia for the spring period centred on March–April was computed to be $1{\cdot}03 \times 10^{36}$ gm.cm.^{2}. This value was used in conjunction with Munk's figure of $-0{\cdot}4 \times 10^{36}$ gm.cm.^{2} for January, and assuming a sinusoidal distribution for the change of inertia with time, the maximum inertia change occurs at the end of April. The effect of this is about three months out of phase with the observed effect, and would therefore contribute very little.

In view of this, a further investigation has been carried out in which Munk's value for January was discarded, and a recomputation for January–February made on the same basis as for March–April. A value of $1{\cdot}22 \times 10^{36}$ gm.cm.^{2} was obtained, and combining this with the March–April figure results in an absolute maximum value of $1{\cdot}64 \times 10^{36}$ gm.cm.^{2}, occurring at the beginning of February. This result is precisely in phase with the total effect, and is therefore a direct contribution. Moreover, the accumulative effect in time is 0·01 sec. (approximately), which is more than 15 per cent of the observed effect.

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Measurement of the Production of Organic Matter in the Sea by means of Carbon-14

It has often been suggested that by far the greatest production of organic matter on earth is due to the marine plankton algæ. Investigations are, however, extremely scarce. In some few areas the quantities of organic matter produced have been calculated by means of indirect methods, as, for example, from the decrease of nutrient salts or carbon dioxide during a definite period. The quantities calculated are, at best, minimum values for production, as account could be taken neither of the carbon dioxide absorbed from the atmosphere or produced by respiration of animals and bacteria, nor of the nutrient salts regenerated during the period and utilized again[1].

A very few coastal waters have been investigated using a proper method for giving the production of matter directly. The only method employed hitherto has been that devised by Gran[2] of suspending samples of sea water containing its natural plankton in the sea. The increase of the oxygen content is estimated after a certain period of time, mostly 24 hr. The determination of oxygen in the water is carried out with greatest accuracy when the production of matter is being measured in productive coastal waters. In oligotrophic waters and in waters with a great depth of the photic zone (production calculated per volume of water therefore small) Gran's method is unserviceable.

When preparing for the Danish oceanographical expedition with the *Galathea*, which was to cover all the oceans, it was therefore found necessary to devise a new method. The radioactive tracer carbon-14 now available made this possible. Preparatory tests were made in Copenhagen during 1950. The method has now been used for a considerable time on board the *Galathea*. It has worked successfully both in very eutrophic and in very oligotrophic waters.

During the cruise of the *Galathea* in the eastern part of the Atlantic from Lisbon to Cape Town, the production of organic matter was measured by this tracer method at fifty-eight stations altogether. The productivity of the ocean in this area was found to vary between about 20 mgm. carbon (near Teneriffe) and about 2,000 mgm. carbon (Benguela Current)

assimilated per square metre per day. A productivity of about 100–200 mgm. carbon per square metre per day was most commonly found.

The main lines of the method are given below. A full description will shortly be published elsewhere. Sterilized glass containers each containing 1 ml. of a solution of sodium bicarbonate ($NaH^{14}CO_3$) were prepared in the laboratory at Copenhagen. Three different concentrations of bicarbonate were available. When the solution from one of these glass containers is poured into sea water with the natural amount of plankton and this water is illuminated, both carbon-12 and carbon-14 will be assimilated during photosynthesis. When afterwards the water is filtered through a collodion filter (maximum size of pores 0·5 μ) all algæ will be filtered off. The filter is then treated with the vapour of hydrochloric acid to remove all carbon in inorganic form. Only tracer carbon in the form of organic matter will be left on the filter. The impulses from the filter are now counted by a Geiger–Müller tube. If the total count of the solution poured into the sea water and also the total carbon dioxide content are known, it is possible to calculate the rate of photosynthesis.

Two slightly different modifications of the method have been used during the cruise of the *Galathea*. The first is to suspend bottles in the sea with sea water collected from the different depth after pouring bicarbonate solution containing tracer carbon into them. An all-glass water sampler is used, and the time between noon and sunset is used for the experiment. As this special method requires the ship to be stationary for a considerable time, it can only be used occasionally. When used together with the second modification, it yields one of the best checks on the validity of this special method.

In the second method the bottles with sea water containing carbon-14 are placed on a rotating plate in a water thermostat illuminated with about 16,000 lux. This light intensity has been found by experiment to give the optimum rate of photosynthesis of marine plankton. Investigations of the dependence of photosynthesis on light were carried out during the expedition, and a standard light-assimilation curve has been constructed.

When the water samples for the experiments were taken, determinations of the penetration of light into the sea were made at the same time. Therefore, if the intensity of the light striking the surface of the sea during all hours of the day is known, it is possible to calculate the light at the different depths. Thus using the values for photosynthesis in optimum light and the standard light-assimilation curve, it is also possible to calculate the actual photosynthesis at the different depths. In this way it is possible to measure the production of organic matter per square metre.

It should be mentioned that it is not absolutely necessary to measure the radioactivity of the filtered plankton on board ship. As the half-life of carbon-14 is at least 5,000 years, there is time enough to make the determination after the end of a cruise. The filters with the algæ on top must be kept in desiccators which do not produce excessive drying.

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March 8.

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Antibiotic Production by Growing Plants of *Leptosyne maritima*

In the course of a routine examination for the presence of antibiotic substances in higher plants, it was found that an antibiotic of high activity was present in *Leptosyne maritima*, a member of the Compositæ.

Dormant seeds of the plant, placed on agar seeded with *Staphylococcus aureus*, gave no inhibition; but after soaking in distilled water an inhibition zone of 18–25 mm. width was formed. Seeds were germinated on slopes of Knop's agar (1 per cent agar), and when the plants had reached a length of about 6 mm. they were transferred for four hours to agar seeded with *S. aureus*. The plants were removed and the plates incubated at 35° C. A zone of inhibition was formed around each seedling (Figs. 1 and 2). It is of particular interest that the antibiotic was exuded freely from both the cotyledons and the roots; the seed-coats also strongly inhibited growth of the bacterium.

In the course of development, the plant produces a stout taproot and a rosette of finely divided leaves. Eventually, the upper part of the taproot and the hypocotyl swell and form a food reserve, and the plant then grows up in the same season to an axis of 30–40 cm. in length, bearing flowers. Plants at the rosette and shooting stage were examined for antibiotic content by taking ½-cm. transverse slices and placing these on *S. aureus* plates. The width of inhibition zone was measured and the results can be seen in Fig. 3. The antibiotic was present in its greatest concentration in the root stock, falling to a negligible amount at the top of the hypocotyl. Very little antibiotic was found in the shoot except at the

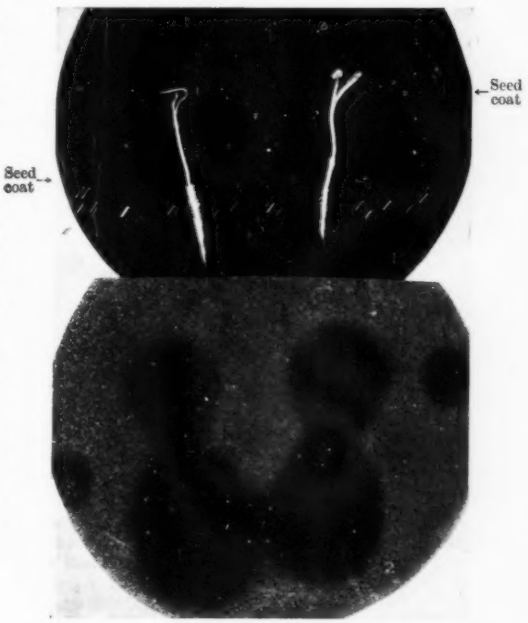

Fig. 1. Seedlings and detached seed coats of *Leptosyne maritima* on *S. aureus* plates

Fig. 2. Plate shown in Fig. 1 after incubation at 35° C. for 24 hr. A few scattered colonies of *S. aureus* resistant to the antibiotic appear in the inhibition zone

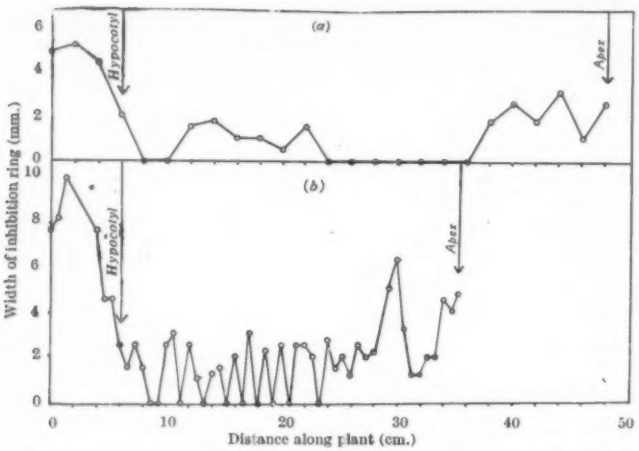

Fig. 3. The distribution of antibiotic in plants of *Leptosyne maritima*, measured by the width of *S. aureus* inhibition given by ½-cm. sections of the plant taken (*a*) at 1-cm. intervals along the plant and (*b*) consecutively. (The width of inhibition ring is approximately logarithmically related to concentration of antibiotic)

stem apex and in very young leaves. No activity was shown by whole leaves, or longitudinally split leaves placed on *S. aureus* plates. Mature leaves extracted by grinding, and tested by the 'hole-in-plate' method, showed only slight activity; but extracts of flowers, made and tested in the same way, showed very strong activity.

Young rootlets, arising from the main rootstock, were placed on plates and a narrow inhibition zone was obtained; but this inhibition was usually obscured by the development of bacterial contaminants on the roots, which grow out over the inhibition zone. Frequently bacterial colonies spread out from the edges of rootstock slices which had been placed on plates, and these bacteria grew freely through the zone of greatest *S. aureus* inhibition.

Plants were grown (*a*) in the open in the Oxford University Botanic Garden and (*b*) in pots in the greenhouse, and the microbial population of the root systems of these plants was compared with that of soil in which plants had not been grown. For this comparison, sample soil dilutions were plated on to soil extract agar with and without crystal violet. The accompanying table shows the results obtained.

(*a*) Plants grown in Botanic Garden; Sampled when Flowering

	Replicates	Bacteria and actinomycetes/gm. soil	Percentage insensitive to 1/10,000 crystal violet
Roots shaken free of loose soil	1	260,000,000	37
	2	110,000,000	30
	3	56,000,000	27
Control soil (1 metre distant from *Leptosyne* plants)	1	15,000,000	13
	2	15,000,000	11
	3	45,000,000	12

(*b*) Plants grown in pots under glass

Replicates	Root surface washings	Soil remaining in pots after removal of roots	Control soil
Percentage of bacteria and actinomycetes insensitive to 1/10,000 crystal violet			
1	18·6	3·5	5·0
2	25·0	5·9	3·8
3	34·2	(0·0)	2·7
Percentage of actinomycetes			
1	8·2	16·6	56·5
2	4·0	21·6	39·7
3	2·5	40·2	54·0

It is clear that the plants exhibit a very strong rhizosphere effect on the total numbers of micro-organisms, percentage actinomycetes and the proportion of the microbial population which is sensitive to 1/10,000 crystal violet. It is noteworthy that, despite the production of the antibiotic, the population of organisms per gram of soil is much higher in the root region than in control soil.

Further experiments are in progress to investigate (*a*) the transport of the antibiotic in the plant, (*b*) the destruction of the antibiotic in the soil and (*c*) the phytotoxic action of the plant exudates, for which we already have evidence in the form of somewhat erratic inhibition of the elongation of lettuce roots.

The preliminary part of this work was carried out by one of us (E. M. O.) in the Sir William Dunn School of Pathology, and the further implications were studied by us jointly in the Department of Agriculture, Oxford. We are grateful to Sir Howard Florey and Prof. G. E. Blackman for making available facilities for this work.

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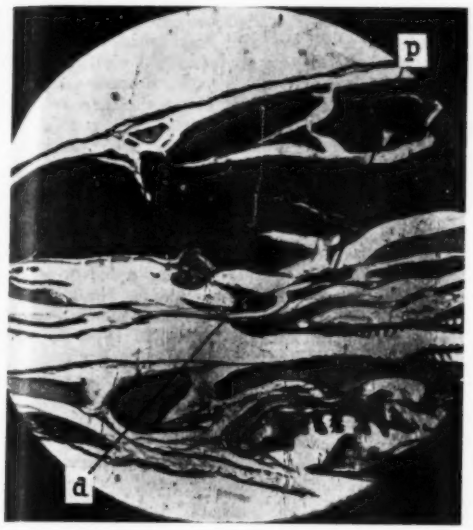
Feb. 22.

Pituitary of *Chanos chanos* Forskål

It is well established by previous workers that the glandular component of the pituitary in teleosts is derived from the ectoderm of the buccal cavity. Haller[1], Matthews[2], and Kerr[3] have observed that the first appearance of the pituitary in all teleosts is as a solid ectodermal inpushing of the buccal epithelium, without any cellular differentiation, which extends below the brain and becomes stalked. This does not at any time possess a hypophyseal cavity.

Studies made on the fry and fingerlings of *Chanos chanos* show, however, a noteworthy peculiarity in this species. The earliest stage of *Chanos* available to me was 14 mm. in total length, and may be estimated as three to four weeks old[4]. The pituitary at this stage has an elongated appearance measuring about 325 μ × 70 μ × 50 μ. A blind diverticulum is seen starting from the roof of the mouth just in front of the beginning of the branchial arches, sloping posteriorly and terminating dorsally at the anterior end of the hypophysis. The cells from this blind end of the diverticulum proliferate to give rise to the glandular elements of the pituitary. To begin with, all the cells of the glandular component are basophilic, but later some of them become acidophilic or even chromophobic in the various regions.



Sagittal section of *Chanos* larva (14 mm.) showing the diverticulum from the buccal cavity connecting it with the pituitary

The point of interest is the connexion of the anterior end of the pituitary (photomicrograph, *p*) with the buccal cavity by means of the diverticulum (*d*). This connexion with the buccal cavity is retained until a comparatively late stage in the life of the fish, but seems to disappear in fingerlings of nearly 53 mm. length. Although a continuous passage from the mouth to the pituitary is not apparent in the later stages, vestiges of the connexion persist close to the hypophysis even in fish measuring 200 mm. in total length. In longer fish, however, the remains of the diverticulum no longer show a well-defined cellular epithelial lining but only a sheet of connective tissue. When the larva grows to about 53 mm. in length, the anterior lobe of the hypophysis develops cavities by the outpushing of the surface of the diverticulum. These hypophyseal cavities appear to be derived from the lumen of the diverticulum, which itself is a continuation of the buccal cavity.

Previous accounts of the development of the pituitary in teleosts have shown that the embryonal connexion of the pituitary with the buccal epithelium disappears immediately after hatching; for example, in *Salmo trutta*, *Clupea harengus* and *Salvelinus willughbyii*[3]. The mode of origin of the cavities in the anterior lobe of the pituitary in these is not clearly known.

Details of this work will be submitted for publication elsewhere. My thanks are due to Dr. N. K. Panikkar, chief research officer, Central Marine Fisheries Station, for his help in the preparation of this note.

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Nov. 10.

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Development of Early Reptile Embryos *in vitro*

Hitherto, the experimental investigation of early reptile embryos has lagged far behind that of fishes, amphibians and birds. Vital marking has been carried out in Chelonia, where the hardness of the shell has made *in ovo* techniques possible[1], but no transplantation experiments appear to have been performed. Such experiments cannot be done *in ovo* because of the difficulty of manipulating tissues which lie beneath the vitelline membrane. This limitation, however, does not apply to material cultured *in vitro*. An attempt has been made, therefore, to find out if young reptile embryos can be grown successfully *in vitro*.

Eggs from the snakes *Natrix natrix* and *Vipera berus*, and from the lizards *Lacerta vivipara* and *Anguis fragilis*, were used. *Natrix* is oviparous, the eggs being laid normally at a relatively late stage of development; the other species are ovoviviparous. In the experiments the eggs were taken from the oviducts. The eggs from each female were usually found to be all at about the same stage of development.

The method of tissue culture used was the watch-glass method employed for chick blastoderms[2]. After explantation on to a clot of fowl plasma and chick-embryo extract, however, the specimens were not incubated but were maintained at room temperature (15–20° C.). It was found that they could live and develop under these conditions for several days, and could then survive transplantation on to a new clot. Out of a total of forty-seven eggs in all, ten were fixed immediately as controls, twenty-two were cultured successfully, and fifteen failed to develop. One batch of ten *Natrix* eggs at a late cleavage stage was cultured without success; specimens were fixed at intervals of two days, and the cells were found on sectioning to have become highly vacuolated and necrotic. Two specimens of *Lacerta* at the blastopore-canal stage were cultured. One was fixed after 24 hr. and found to be still in the blastopore-canal stage though the tissues were healthy. The other specimen was fixed after nine days; it had developed into an embryo with a well-defined neural plate, otic vesicles, notochord, myotomes and gut. Many mitoses were visible.

The remaining specimens obtained were older, with a well-formed embryonic axis at the time of explantation. It was found that embryos possessing twenty to thirty pairs of somites, a beating heart and an amnion could be cultured for several days. Four out of six specimens of *Lacerta* at this stage of development were successfully cultured, one of these being grown for ten days, after transplantation at four days. Seven out of ten specimens of *Anguis* at this stage were also cultured successfully, one specimen being maintained for twenty days, with transplantation at two, nine and fifteen days. It was found on sectioning that very little necrosis had occurred and that differentiation of certain tissues had proceeded furthest in those embryos which had been cultured for the longest periods. Otic vesicles, nasal pits and nephric tubules were absent in *Anguis* embryos fixed after two days (two specimens) or four days (three specimens), present in a specimen grown for nine days, and still further advanced in the embryo cultured for twenty days. Pharyngeal pouches were present in the younger but not in the two older embryos. In the specimen grown for twenty days, the notochord had assumed the highly

vacuolated form characteristic of advanced embryos, whereas in the younger specimens the notochords had remained small and non-vacuolated. The development of the heart had been considerably disturbed, however, in the specimen grown for twenty days.

The *Vipera* embryos were all at an older stage when obtained. One specimen, which had a small allantoic bud, was cultured for four and a half days. During this time, the embryo lengthened and the allantois increased to about twice its original size and applied itself to the inner surface of the chorion.

The present experiments indicate that certain young embryos of British reptiles can survive and develop fairly normally *in vitro* for several days. It is suggested that by use of this technique a wide range of experimental work may become possible.

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Benzalcoumaranones

The discovery of the first benzalcoumaranone in Nature in the flowers of *Coreopsis grandiflora*[1] has recently been followed by that of a second, aureusin, in *Antirrhinum majus*[2]. It would seem to be in the interest of biochemists and geneticists working in the field of plant pigmentation to introduce a less cumbersome term than 'benzalcoumaranone' for this class of pigments. In view of the golden-yellow colour which they impart or contribute to flowers in which they occur, and on the analogy of the term 'flavone' applied to the paler yellow pigments containing the pyrone ring, we suggest the term 'aurone' be employed in referring to the naturally occurring benzalcoumaranones.

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Los Angeles 24, California. March 12.

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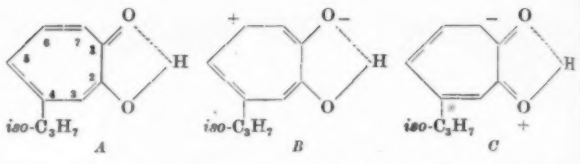
Dipole Moments of Tropolone and Related Compounds

One of us (T. N.) has carried out extensive studies[1] on the chemical properties of hinokitiol (4-*iso*propyl-*cyclo*heptatrien-2,4,6-ol-2-one-1) and assumed its structure to be the resonance hybrid among various electronic structures of the types, *A*, *B* and *C* [2]. He also succeeded in synthesizing this compound and its mother substance, tropolone.

We have measured the dipole moments of some of these compounds[1,2] in benzene solution and have found the following values: tropolone (I, m.p. 51°), 3·71 *D.* (25°) and 3·64 *D.* (35°); tribromotropolone (II, m.p. 126°), 1·84 *D.* (25°); hinokitiol (III, m.p. 52°), 4·04 *D.* (33°); α-monobromohinokitiol



(IV, m.p. 56°), 4·32 *D.* (33°); α-dibromohinokitiol (V, m.p. 134°), 4·27 *D.* (33°); β-dibromohinokitiol (VI, m.p. 96°), 3·14 *D.* (20°); α-mononitrohinokitiol (VII, m.p. 56°), 6·19 *D.* (25°).

The dipole moments of I and III are much greater than can be accounted for by simple vector addition of bond moments using the valence bond structure of type *A*. They can be explained if we take into consideration the ionic structure of type *B*, with a formal positive charge at the ring-carbon atoms. This will give some degree of double-bond character to each bond in the ring, giving a plane *cyclo*heptatriene ring. The direction of dipole moment in the molecule of III can be determined in the following manner. We assume that the moment of IV is the vector sum of that of III and the C–Br bond moment. It is highly probable from consideration of the course of its formation that the bromine atom is in position 7. Hence the C–Br moment is in the direction from the centre of the ring to carbon atom 7. From simple geometry, using measured moments, it is concluded that the moment of hinokitiol is nearly in the direction from the centre of the ring to the middle point between two oxygen atoms. The moments of dibromohinokitiols and nitrohinokitiol can be calculated theoretically for various positions of substitution for comparison with the observed values. The conceivable position is at the carbon atoms 3, 5 and 7, as is evident from the molecular orbital treatment to be discussed later. Then the positions of substitution are 3, 5, 7 for II, 3, 7 for V, 5, 7 for VI and 7 or 3 for VII.

We have carried out molecular orbital treatment similar to that by Wheland and Mann[3] on methylene-*cyclo*heptatriene and tropolone, simplifying the problem as π-electron systems with due regard to the electronegativity of oxygen. We arrived at a reasonable moment with the positive end at the ring. The resonance energies of *cyclo*heptatriene and tropolone were found to be 1·994 β and 3·09 β, respectively, as compared with 2 β for benzene. In the molecule of tropolone, π-electron distribution was found to be concentrated at carbon atoms 3, 5 and 7, which justifies our previous assumption that only carbon atoms 3, 5 and 7 are attacked by electrophilic reagents.

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[The following notes on related work by European and American workers will be of interest.—Editors.]

The investigations of Erdtman and his collaborators[1] have shown that hinokitiol is identical with β-thujaplicin, which they isolated from the heart-

wood of *Thuja plicata*. This identity is implicit in the structure assigned by Prof. Kubo and his collaborators to hinokitiol. It has been established for β-thujaplicin by Anderson and Gripenberg[2], and has recently been confirmed by synthesis[3]. It is stated in the above communication that Prof. Nozoe has synthesized hinokitiol and also the parent compound tropolone, but no reference to the publication of this work is given. Tropolone has been synthesized and its chemistry investigated by Cook *et al.*[4], and by Doering and Knox[5]. Dipole moment measurements on β-methyltropolone and one of its methyl ethers have been recorded by Mills and Tyrell[6].

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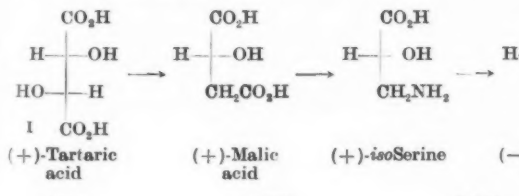
Configurational Notation of the Tartaric Acids

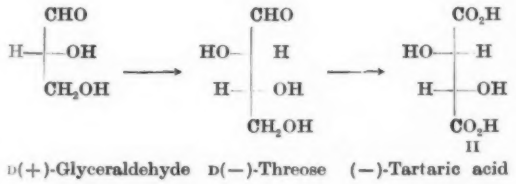
In an abstract of a paper describing a method of preparation of (−)-tartaric acid from D-xylose the acid is named L(−)-tartaric acid[1]. As this seemed odd, a number of standard text-books were consulted; these were about equally divided in naming dextro-rotatory tartaric acid D(+) or L(+). This confusion arises because the relationship of the tartaric acids to the reference compound D(+)-glyceraldehyde has been established in two different ways, from which opposite conclusions have been drawn:

(+)-Tartaric acid is related to D(+)-glyceraldehyde by the series of reactions[2]: (+)-tartaric acid → (+)-malic acid → (+)-*iso*serine → (−)-glyceric acid → (+)-glyceraldehyde: hence D(+)-tartaric acid.

(−)-Tartaric acid is obtained by oxidation of D-threose, which is related in configuration to D(+)-glyceraldehyde: hence D(−)-tartaric acid.

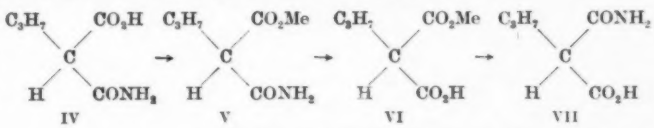
If D(+)-glyceraldehyde is represented by the conventional projection formula III, these reactions can be formulated as follows:





Both series lead to the same *configuration* for (+)-tartaric acid; that is, if D(+)-glyceraldehyde is (III), then (+)-tartaric acid is (I) and (−)-tartaric acid is (II). The only point at issue is which tartaric acid should be labelled 'D'? If a choice must be made, D(−)-tartaric acid seems preferable; the *lævo* acid may be regarded as built up, in the same manner as the sugars, by addition to the aldehyde group; the *dextro* acid may be regarded as built up by addition to the primary alcohol group.

Any attempt to classify all optically active compounds into D- and L-series is obviously absurd. This is brought out most clearly by considering the classical experiments of Fischer and Brauns, in which (+)-*iso*propylmalonamic acid was converted into its enantiomorph by interchanging two groups attached to the asymmetric carbon atom. The essential steps in the process may be represented thus:



As none of these transformations changes any bond of the asymmetric carbon atom, each compound is 'similar in configuration' to its neighbour, so that, overall, (IV) would appear to be 'similar in configuration' to its enantiomorph (VII). Clearly the fallacy in this reasoning is that the viewpoint from which the configurations are observed has been altered. Now if (IV) is labelled D-, (VII) must be L-, but where has the change occurred? It might be placed at the step (V) → (VI), since a second group on the asymmetric centre is altered at this stage; but in that case (V) and (VI), although similar in configuration and differing in only one group, will be placed in opposite configuration series.

The impossibility of assigning the symbols D- and L- unambiguously is also illustrated in experiments by Levene and Marker in which they showed that (+)-β-methyl-*n*-valeric acid and (+)-ζ-methyl-*n*-hexoic acid are *opposite* in configuration since they can be converted into the *same* dextrorotating γ-methyl-*n*-hexane[3]; or by the experiments of Barrow and Ferguson, in which (+)-alanine and (+)-valine are shown to have the *same* configuration because they can be converted into the *opposite* forms of α-methyl*iso*butylamine[4].

If the two ways in which the tartaric acids are related to (+)-glyceraldehyde are combined, the complete series of transformations could be regarded as the conversion of (+)-tartaric acid into its enantiomorph. In this case also a change of viewpoint must have occurred, and this is most plausibly assigned to the step (+)-*iso*serine → (−)-glyceric acid; this leads to the notation L(+)-tartaric acid, L(+)-malic acid, L(+)-*iso*serine, D(−)-glyceric acid. Brewster, Hughes, Ingold and Rao recently established the configurational relationship of D-glyceraldehyde and D-serine[5], the principal step being the relationship (−)-lactic acid ← (+)-*iso*serine → (−)-glyceric acid. As shown above, the step (+)-*iso*serine → (−)-glyceric acid may be considered to involve a change of viewpoint; it is a matter of opinion whether or not the step (+)-*iso*serine → (−)-lactic acid involves a similar change, but if it does, the conclusion that D-glyceraldehyde 'corresponds in configuration' to D-serine is not affected.

Although the relative configurations of many optically active compounds can be established, it is impossible to allocate the compounds to D- and L-series without ambiguity. This is true even in carbohydrate chemistry; for example, (+)-saccharic acid

is related in the same way to D-glucose and L-gulose. Nevertheless, the use of these prefixes is increasing. An optically active benzenehexachloride has been designated D(−)-1 : 2 : 3 : 4 : 5 : 6-hexachlorocyclohexane[6], although how a compound with no asymmetric carbon atom can 'correspond in configuration' to D-glyceraldehyde defies comprehension. Crombie and Harper propose the addition of a new category based on (+)-2-methylbutanol[7]. Surely, it would be better to abandon the use of the prefixes 'D-' and 'L-', except for those parts of the carbohydrate and α-amino-acid fields in which they do serve a useful purpose.

Note added in proof. Cahn and Ingold[8] have proposed a new convention, for the specification of configuration, which is free from the ambiguities of the current system.

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Nov. 24.

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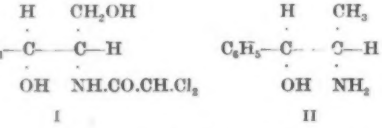
[8] *J. Chem. Soc.*, 612 (1951).

Configurational Correlation of Chloramphenicol and of *nor*-pseudo-Ephedrine

Recently, acyl migration N → O was recognized[1] to be stereo-specific in the chemistry of diastereoisomeric 1.2-amino-alcohols, and thus suitable for the determination of the configuration[2] in this series of compounds.

After the structure (I) of chloramphenicol (Parke Davis 'Chloromycetin') had been established[3], its potential antibiotic activity rendered of interest the decision as to whether (I) belongs stereochemically to the ephedrine or to the pseudo-ephedrine (II) series.

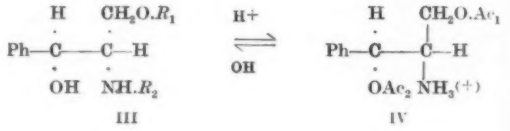


Crooks *et al.*[3] assumed on the basis of optical rotation data that by analogy (I) is sterically related to *nor*-pseudo-ephedrine[4].

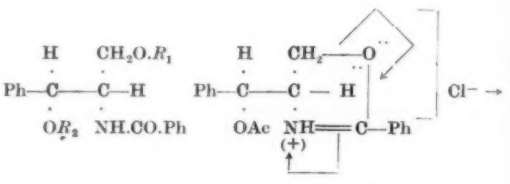
We have now reached a precise decision by using two different methods. First, 1-phenyl-2-amino-propandiol-1.3 (III *a*), melting point 86°[5], sterically related to I, was converted into its N-benzoyl-O_3-acetyl and O_3.N-diacetyl derivative (m.p.'s 132° and 168°), respectively. The primary hydroxyl group having been acylated previously, acyl migration N → O could only take place towards the secondary hydroxyl group at the asymmetric carbon 1. III *b* and *c* become rearranged instantaneously on the action of absolute alcoholic hydrochloric acid into the hydrochlorides (m.p.'s 182° and 177°) of the corresponding $O_1.O_3$ diacyl derivatives (IV) with retention of configuration, similarly to N-acyl-pseudo-ephedrines[1]. On the other hand, in the case of the diastereoisomers of III *a* and of III *b* under strictly identical conditions, acyl migration could not be observed. Consequently, we suggested for III as well as for chloramphenicol the conformation and the configuration of pseudo-ephedrine.

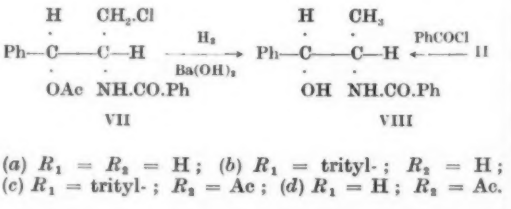
A second proof of the stereochemical correlation of chloramphenicol with psi-ephedrine consisted of the reductive elimination of the primary hydroxyl group of 1-phenyl-2-benzamido-propandiol-1.3 (V *a*), melting point 165°, related sterically[6] to III and to I. Details of this work will be reported elsewhere[6].

The 3-trityl derivative of V *b* (m.p. 186°) was acetylated to V *c* (m.p. 144°); this, in turn, was hydrogenated in order to split off the trityl group. Surprisingly, in neutral medium, hydrogenolysis only affected the acetoxy group, whereas proton catalysis in hydrogenation resulted in the selective removal of the trityl group, furnishing 1-phenyl-1-acetoxy-2-benzamido-propanol-3 (V *d*, m.p. 126°). Careful acidolysis yielded the same compound. Thionyl chloride in ethyl acetate converted the latter into an oxazolinium salt (VI), which, in turn, similarly to other oxazolines[7], became rearranged during recrystallization—presumably *via* the carbonium salt—into the ω-chloro-derivative (VII, m.p. 133°). Hydrogenolysis of VII was carried out in alcohol over palladized charcoal in the presence of barium hydroxide, yielding quantitatively N-benzoyl-*dl*-*nor*-pseudo-ephedrine (VIII, m.p. 128°), identical with an authentic specimen[1b]. Obviously, barium hydroxide effected during the hydrogenation a simultaneous Kunz hydrolysis of the acetyl group.



III (*a*) $R_1 = R_2 = H$; (*b*) R_1 = Ac, R_2 = Bz; (*c*) $R_1 = R_2$ = Ac.





(*a*) $R_1 = R_2 = H$; (*b*) R_1 = trityl-; $R_2 = H$; (*c*) R_1 = trityl-; R_2 = Ac; (*d*) $R_1 = H$; R_2 = Ac.

In this series of reactions, retention of configuration was proved in each step by several interconversions[6]. Thus our results show the configurational correlation of chloramphenicol (I) and pseudo-*nor*-ephedrine (II).

This work thus forms part of the series of experiments establishing the stereochemical correlation of the pharmacologically most active phenyl-propanol-

amines (for example, *p*-hydroxy- and dihydroxy-*nor*-ephedrine ('Corbasil') and ephedrine).

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Nov. 18.

[1] (*a*) Fodor, G., and Kiss, J., *Nature*, **163**, 287 (1949). (*b*) Fodor, G., *et al.*, *J. Org. Chem.*, **14**, 337 (1949); (*c*) Welsh, L. H., *J. Amer. Chem. Soc.*, **69**, 128 (1947).
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[4] Our projection formulæ tend to reflect, in agreement with Close, W. J., *J. Org. Chem.*, **15**, 1131 (1950), the *cis* conformation of amino- and hydroxyl-groups in pseudo-ephedrines. The configurations are those established by Freudenberg, K., *J. Amer. Chem. Soc.*, **54**, 234 (1932); cf. Welsh, *ibid.*, **71**, 3500 (1949).
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A Coproporphyrin Chromogen excreted in Normal and Pathological Urine

During an investigation of the conversion products of porphobilinogen in the urine in cases of acute porphyria, it was observed that the fluorescence of the ether/glacial acetic acid extracts of the urine increased considerably when the extracts were left at room temperature for a day or two. This might indicate the formation of coproporphyrin from a chromogen extracted by ether/glacial acetic acid, and such a chromogen has not apparently been previously described.

Table 1. Coproporphyrin (γ/100ml.) Excreted in the Urine of Four Normal Adults

Sex	Preformed	Formed from chromogen	Total	Normal
♂	4·2	9·6	13·8	<7
♂	5·4	6·6	12·0	<7
♀	8·4	15·2	23·6	<7
♀	4·5	11·1	15·6	<7

Table 2. Coproporphyrin (γ/100ml.) Excreted in the Urine in Two Cases of Lead Poisoning

Sex	Preformed	Formed from chromogen	Total	Normal
♂	378·4	200·0	578·4	<7
♂	100·9	228·9	329·8	<7

Urine from four normal adults and from two adults suffering from lead poisoning was examined. The urines were extracted with ether/glacial acetic acid by H. Fischer's method[1], and the coproporphyrin extracted with 0·1 *N* hydrochloric acid. The amount of coproporphyrin was determined by Rimington and Sveinsson's method[2]. The ethereal fractions were washed several times with 0·1 *N* hydrochloric acid and distilled water, left at room temperature for three days, and extracted again with 0·1 *N* hydrochloric acid. The solution obtained showed an intense red fluorescence. Examination in a Beckman spectrophotometer gave a typical coproporphyrin spectrum, with a distinct maximum at 401 mμ. The amount of coproporphyrin was determined (see Tables 1 and 2).

Porphobilinogen was not adsorbed on calcium phosphate when the urine was treated according to Sveinsson, Rimington and Barnes[3], and there was reason for believing that the same was the case with the coproporphyrin chromogen. The urines from the two patients suffering from lead poisoning were therefore treated by this method. The calcium phosphate precipitate was centrifuged down, washed several times with distilled water, and dissolved in dilute hydrochloric acid. The *p*H was brought to about 5·0, and the solution was extracted with ether/glacial acetic acid. The coproporphyrin was extracted with 0·1 *N* hydrochloric acid, and the amount determined (see Table 3). The filtrates were acidified to about *p*H 5·0, extracted with ether/glacial acetic acid, and left at room temperature for three days. Then the coproporphyrin formed was extracted with 0·1 *N* hydrochloric acid, and the amount determined (see Table 3). In all cases extraction with hydrochloric acid was continued until no fluorescence could be observed in the acid phase.

Table 3. Coproporphyrin (γ/100ml.) Excreted in the Urine of Two Cases of Lead Poisoning
(The preformed porphyrin is adsorbed on calcium phosphate; the chromogen is extracted with ether/glacial acetic acid and converted)

Sex	Preformed adsorbed	Formed from chromogen	Total	Normal
♂	382·4	199·0	581·4	<7
♂	92·7	209·7	302·4	<7

As seen from the tables, the coproporphyrin is only in part excreted as such in the urine. A considerable part, in some cases up to three-quarters of the total, is excreted as a colourless chromogen, which can be extracted with ether/glacial acetic acid and is converted to coproporphyrin on standing at room temperature. Maximum conversion is attained in three days.

Neither the coproporphyrin chromogen nor porphobilinogen is adsorbed on calcium phosphate, whereas the porphyrins are totally adsorbed. The preformed porphyrins and the chromogens may therefore easily be separated by the procedure of Sveinsson, Rimington and Barnes. Further investigations of the conversion of the chromogen to coproporphyrin and attempts to identify the chromogen are in progress.

The complete report of this investigation will be published in the *Scand. J. Clin. and Lab. Investigation*.

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Ullevål Hospital,
Oslo.
Dec. 6.

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[2] Rimington and Sveinsson, *Scand. J. Clin. and Lab. Invest.*, **2**, 3 (1950).
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Adrenocorticotropic Hormone in the Pituitary Gland of the Whale

A recent communication by Böe *et al.*[1] on adrenocorticotropic hormone in the whale prompts us to communicate our own preliminary results on the isolation of this hormone from whale pituitaries. We, however, used the anterior lobe of the whale gland only, and obtained, by Lyons's well-known acid acetone extraction procedure[2], from 1 kgm. of the frozen glands from mixed blue, fin and humpback whales, with blue and fin predominating, 4·0 gm.

of the so-called 'crude prolactin'. A preliminary purification of this preparation was possible by simple reprecipitation from acid aqueous acetone solution, followed by Chamberland filtration of the watery solution of the precipitate thus obtained, and finally by lyophilizing the resulting clear extract. In this manner, 0·9 gm. of a whitish, easily soluble powder was obtained, which, when assayed by the ascorbic acid depletion method of Sayers[3], showed an adrenocorticotropic activity nearly equal to that of the Armour *La*-1-*A* standard, and was completely free from pressor activity (posterior lobe hormone).

Attempts to isolate a pure preparation of the adrenocorticotropic hormone of whale pituitaries according to the method of Fishman[4] resulted in much loss of active material; furthermore, the activity of the final product was not considerably increased over that of the reprecipitated hormone preparation mentioned above.

We were, however, successful in obtaining an active dialysate of our reprecipitated adrenocorticotropic extract by pepsin digestion, rapid dialysis of the digestion mixture in 'Cellophane' tubes (Visking Corp., Chicago) and freeze-drying the outer solution. Biologically active peptides[5] have already been obtained from adrenocorticotropic hormone preparations derived from pituitaries of sheep, pig and ox; we were able to confirm these findings. Our crude dialysate from whale pituitary (90 mgm. from 500 mgm.) showed nearly the same activity (ascorbic acid depletion method) as the starting material. The activity of the solution inside the 'Cellophane' tubes had decreased relatively little, showing that hydrolysis and dialysis were far from complete. It is therefore desirable to increase the yield of the active dialysable fraction and furthermore to obtain it in more concentrated form. Experiments for this purpose will be described elsewhere.

Fritz Benz
Werner Schuler
Albert Wettstein

Ciba Research Laboratories,
Basle. March 8.

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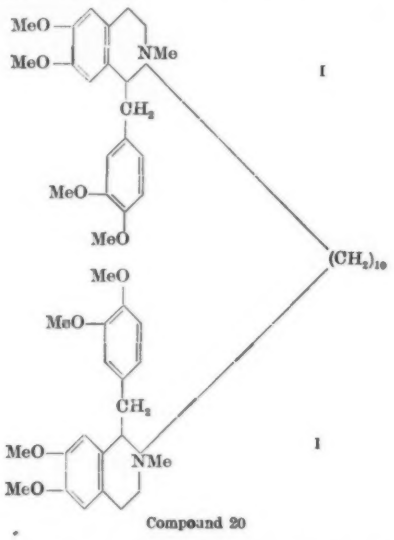
Synthetic Curarizing Agents structurally related to *d*-O.O-Dimethyltubocurarine

d-Tubocurarine and its dimethyl ether have established places for themselves as muscle relaxants in anæsthesia. It is therefore of practical as well as theoretical importance to investigate the curarizing properties of synthetic compounds which are very closely related to these curare derivatives. In a previous communication[1], we showed that decamethylene-αω-*bis*-6 : 7 : 8-trimethoxy-1.2.3.4-tetrahydro-*iso*-quinolinium methiodide (compound 15) possesses activity approaching that of *d*-O.O-dimethyltubocurarine in the rabbit, and we have pointed out the strong chemical resemblance between the two substances.

In continuing this work, we have investigated compounds still more closely related structurally to *d*-O.O-dimethyltubocurarine. The alkaloid laudanosine very closely resembles one half of the molecule of the curare derivative, and it is therefore not surprising that some of the mono-quaternary salts of laudanosine possess slight curarizing properties[2]. Consequently it was decided to prepare some polymethylene *bis* quaternary salts of laudanosine. These were obtained either by (i) refluxing an excess of the alkaloid with a polymethylene dihalide in benzene solution; or (ii) refluxing tetrahydropapaverine with a polymethylene dihalide in benzene solution, and treating the resultant *bis* tertiary amine with a methyl halide or sulphate.

One of the compounds so obtained was decamethylene-αω-*bis*-[1(3′.4′-dimethoxy benzyl)-6.7-dimethoxy-1.2.3.4-tetrahydro-*iso*-quinolinium methiodide] (compound 20). It will be seen from the formula that this compound bears a closer chemical relationship to *d*-O.O-dimethyltubocurarine iodide in its essential features than do any of the compounds previously described by us.



Compound 20

The paralysing activity of this substance has been investigated in various animal species. In the cat it is considerably more active than *d*-tubocurarine, although not quite so active as *d*-O.O-dimethyltubocurarine in curarizing the tibialis muscle. In this animal, compound 20 is more active than compound 15, while it is less active in the rabbit; and both compounds are about equally active in the mouse. As with compound 15, compound 20 shows affinities with decamethonium salts, and contrasts with curare derivatives in possessing relatively low paralysing activity in the rat. The fact, however, that the present compound is antagonized by neostigmine emphasizes its closer relationship to the curare type of paralysant.

Paton and Zaimis[3] have shown that decamethonium iodide is of appreciably shorter duration of action than *d*-tubocurarine in the cat. While for equipotent doses the duration of action of compound 15 is of the same order as decamethonium iodide in this animal, the duration of action of compound 20 is of the same order as that of *d*-tubocurarine chloride.

At present, only the racemic forms of laudanosine and of tetrahydropapaverine have been employed in preparing compound 20. Work on the resolution of laudanosine is now in progress, and in due course we hope to investigate the properties of the *bis* quaternary ammonium salts prepared from the stereoisomers.

We wish to express our thanks to Mr. W. C. Austin for help in the chemical work, and to Miss M. P. Hatton and Mr. R. A. Hall for help in the pharmacological work. We also wish to thank the directors of Allen and Hanburys, Ltd., for permission to publish this communication.

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H. O. J. Collier

Research Division,
Allen and Hanburys, Ltd.,
Ware, Herts. Jan. 22.

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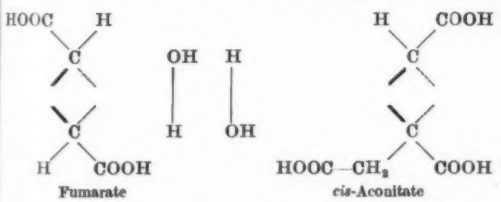
Specificity of the Enzyme Aconitase

Because the enzyme named 'aconitase'[1] catalyses the conversion of *cis*-aconitate both to citrate and to *iso*citrate (and the reverse reactions), it has been thought[2] that it may be a mixture of two enzymes, though Buchanan and Anfinsen[3] found no evidence of this.

As in the case of hydration of fumarate to malate[4], it is necessary to assume that H_2O is added exclusively to one member of the double bond of *cis*-aconitate, in order to explain the formation of optically active products. This necessitates, in both cases, the assumption of a 'three-point attachment' of the substrate to the enzyme[5]. The formation of citrate or *iso*citrate depends only on the direction of addition of H_2O.

Now it is not necessary to assume that there is any preferred direction of addition of H_2O to fumarate (relative to the asymmetric enzyme), since addition in either direction (see formulæ) yields the same



Fumarate *cis*-Aconitate

isomer of malate. This makes it likely that with *cis*-aconitate also there is no preferred direction and, thence, that citrate and *iso*citrate may be formed by the action of a single enzyme. It is of interest that Martius and Lynen[6] have shown that the initial rates of formation of citrate and *iso*citrate are approximately equal. The occurrence of the reverse reactions follows from the requirement of catalytic reversibility.

A. G. Ogston

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Oxford. Dec. 12.

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Formation of Hydroxylamine from Amino-Compounds in Aqueous Solution by Irradiation with X-Rays

In recent studies of the effects of ionizing radiations on aqueous solutions of compounds containing amino-groups such as, for example, amino-acids[1], adenine[2], nucleic acids[2,3], it has been shown that, among other changes, ammonia is formed. In the case of the nucleic acids, for example, the ammonia arises from the constituent purine and pyrimidine bases as a result of a deamination process involving the radicals OH and HO_2, which are formed in the primary radiation process according to[4]:

$$H_2O \text{ —}\sim\sim\sim\rightarrow H + OH,$$

which in the presence of oxygen is followed by:

$$H + O_2 \rightarrow HO_2.$$

It may be expected that an attack by these radicals on the primary amino-groups ($-NH_2$) in the bases adenine, guanine and cytosine, and also in other amino-compounds, may, in addition, give rise to some hydroxylamine. By irradiation with X-rays of aqueous solutions of these bases, and also of their corresponding nucleosides and nucleotides, we have established that this process does, in fact, take place to some extent.

The presence of hydroxylamine was established by well-known colour reactions and also by a paper-chromatographic method which was developed for this purpose. Quantitative determinations of the yields, for example, from adenine, show that doses of the order of 100,000 r. produce a concentration corresponding to about 1×10^{-6} moles/litre of hydroxylamine. However, only very small amounts are formed on irradiation of the nucleic acids. That the amino-group is the source of hydroxylamine is again demonstrated by the absence of this substance in irradiated solutions of, for example, hypoxanthine, uracil and uridine, in which cases no amino-groups are present.

Other compounds containing the primary amino-grouping have also been examined, and it has been found that hydroxylamine is produced in the irradiation of aqueous solutions of certain amino-acids (for example, alanine, lysine) and of certain amines (for example, ethylamine, histamine). In general, the yields of hydroxylamine depend markedly upon the *p*H of the irradiated solutions.

These observations may be of biological significance in view of the possible formation of hydroxylamine *in vivo* from amino-compounds present in tissues, as it is well known that hydroxylamine is a strong cell poison and a very effective catalase inhibitor.

On the other hand, we found that irradiation of ammonia does not yield hydroxylamine. Irradiation of ammonium salt solutions with X-rays results predominantly in an oxidation to nitrite, a reaction which depends markedly on the hydroxyl ion concentration and which is also enhanced by the presence of molecular oxygen. This oxidation process is of interest in view of the corresponding process occurring in plants and in nitrifying bacteria.

George Scholes
Joseph Weiss

King's College, University of Durham,
Newcastle upon Tyne. Feb. 27.

[1] Stein, G., and Weiss, J., *Nature*, **162**, 814 (1948); *J. Chem. Soc.*, 3256 (1949). Dale, W. M., and Davis, J. V., *Nature*, **163**, 64 (1949). Dale, W. M., Davis, J. V., and Gilbert, C. W., *Biochem. J.*, **45**, 93 (1949).
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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, April 30

University of London (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. H. W. Turnbull, F.R.S.: "The Discovery of the Infinitesimal Calculus".* (Further Lectures on May 2 and 4.)

Tuesday, May 1

Institution of Electrical Engineers, Measurements Section (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Prof. P. Fourmarier: "The Measurement of Natural Frequencies of Power Networks".

University of London (in the Chemistry Lecture Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. R. B. Woodward: "Recent Advances in the Chemistry of Natural Products".* (Further Lectures on May 3 and 7.)

Manchester Geographical Society (at the Geographical Hall, 16 St. Mary's Parsonage, Manchester), at 6.30 p.m.—Mr. Norman H. Zimmern: "Travels in Colombia and Neighbouring Countries".

Wednesday, May 2

Physical Society (at the Royal Institution, 21 Albemarle Street, London, W.1), at 4.30 p.m.—Annual General Meeting; at 5 p.m.—Prof. S. Chapman, F.R.S.: "Some Phenomena of the Upper Atmosphere" (Presidential Address).

Society of Public Analysts and other Analytical Chemists (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 7 p.m.—Mr. G. H. Bush and Mr. D. G. Higgs: "The Estimation of Boron in Boronised Metals"; Mr. H. J. Cluley: "The Determination of Germanium".

Thursday, May 3

Royal Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Prof. W. H. McCrea: "Relativity Theory and the Creation of Matter"; Mr. J. F. Nye: "The Flow of Glaciers and Ice-sheets as a Problem in Plasticity".

University of London (in the Hatton Lecture Theatre, Queen Mary College, Mile End Road, London, E.1), at 5 p.m.—Prof. J. Eric Smith: "The Teaching of Zoology in the Universities" (Inaugural Lecture).*

Institution of Electrical Engineers, Utilization Section (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. W. D. Chesterman, Mr. D. R. Glegg, Mr. G. T. Peck and Mr. A. J. Meadowcroft: "A New Power Stroboscope for High-Speed Flash Photography".

Physical Society, Acoustics Group (in the Small Physics Theatre, Imperial College of Science and Technology, Imperial Institute Road, London, S.W.7), at 5.30 p.m.—Mr. P. Westervelt: "The Interaction of Finite Amplitude Acoustic Waves with small Obstacles and Orifices".

Chemical Society (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Prof. H. C. Urey, For.Mem.R.S.: "Chemical Evidence relative to the Origins of the Earth and Planets".

Friday, May 4

University of London (in the Clinical Lecture Theatre, Middlesex Hospital, London, W.1), at 4 p.m.—Sir Edward Mellanby, F.R.S.: "The Chemical Manipulation of Food" (Sanderson-Wells Lecture).*

University of London (in the Embryology Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. S. S. Wilks (Princeton): "Order Statistics".* (Further Lectures on May 9 and 16.)

Royal Statistical Society, London Group of the Industrial Applications Section (at the E.L.M.A. Lighting Service Bureau, 2 Savoy Hill, London, W.C.2), at 6 p.m.—Annual General Meeting; Dr. E. A. G. Knowles and Miss E. Roseman: "Graphical Analysis of Variations as a Production Tool".

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. W. T. Astbury, F.R.S.: "Hairs, Muscles and Bacterial Flagella".

Saturday, May 5

Biochemical Society (in the Department of Biochemistry, The University, South Parks Road, Oxford), at 11 a.m.—Scientific Papers.

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant (scientific) in the Grain Drying Department to work in the Engineering Laboratory (electrical experience essential, and an interest in electronics would be preferred)—The Secretary, National Institute of Agricultural Engineering, Wrest Park, Silsoe, Beds (May 5).

Experimental Officer in the Agricultural Testing Department, with experience in the use of scientific measuring apparatus, an Assistant Experimental Officer, and an Assistant (scientific) with practical general farming experience and experience of handling machines in the field—The Secretary, National Institute of Agricultural Engineering, Wrest Park, Silsoe, Beds (May 5).

Experimental Officer in the Horticultural Department, to carry out spraying investigations—The Secretary, National Institute of Agricultural Engineering, Wrest Park, Silsoe, Beds (May 5).

Lecturers (3) in the Department of Education: (*a*) to be responsible for the methods of teaching history, the history of education, and some work in comparative education, (*b*) to be responsible for the methods of teaching biology and for work in health education, (*c*) to be responsible for the methods of teaching English and for some work in educational psychology—The Registrar, University College of North Staffordshire, Keele, Stoke-on-Trent (May 5).

Lecturers or Senior Lecturers in Physics and Chemistry, and a Senior Lecturer in Mathematics, at Fourah Bay College, Sierra Leone—The Secretary, Advisory Committee on Colonial Colleges of Arts, Science and Technology, 15 Victoria Street, London, S.W.1 (May 5).

Principal Psychologist (temporary), who will form one of a team of specialists, to be established by the Ministry of Labour and National Service in London, for the purpose of developing and improving methods now practised in the Ministry's Industrial Rehabilitation Units—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting G.139/51A (May 5).

Scientific Officer in the Field Investigation Department, to take charge of an investigation into factors affecting the successful and economical mechanization of crops in the United Kingdom, and Assistant Experimental Officers to take part in investigations as part of team working under the Scientific Officer—The Secretary, National Institute of Agricultural Engineering, Wrest Park, Silsoe, Beds (May 5).

Senior Experimental Officer to take charge of an Information Section comprising library, abstracts, publications, and a small film and photographic unit, and an Experimental Officer to undertake advisory correspondence, abstracts and general duties within the Section—The Secretary, National Institute of Agricultural Engineering, Wrest Park, Silsoe, Beds (May 5).

Educational Psychologist (woman)—The Chief Education Officer, County Education Office, Trull Road, Taunton (May 7).

Demonstrator or Assistant Lecturer in the Department of Physiology—The Secretary, Bedford College for Women, Regent's Park, London, N.W.1 (May 11).

Lecturers (3) in the newly established Postgraduate School of Applied Mechanics—The Registrar, The University, Sheffield (May 12).

Professor of Physiology, and a Professor of Comparative Anatomy (Marine Zoology preferred), at Farouk I University, Alexandria—The Director-General, Egyptian Education Bureau, 4 Chesterfield Gardens, London, W.1 (May 12).

Assistant Lecturer (preferably with some specialist knowledge of physical chemistry) in the Department of Chemistry—The Secretary and Registrar, University College of North Wales, Bangor (May 14).

H.M. Inspectors of Factories (Class II, men and women) in the Ministry of Labour and National Service—The Secretary, Civil Service Commission, 6 Burlington Gardens, London, W.1, quoting No. 152/51 (May 15).

International Wool Secretariat Wool Research Scholarships—The Registrar, The University, Manchester 13 (May 15).

Lecturer in Mathematics at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (May 18).

Lecturer in Mining—The Registrar, King's College, Newcastle-upon-Tyne (May 19).

Research Officer (Biologist) in the Division of Fisheries, initially at Hobart, Tasmania—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 3375 (May 19).

Experimental Officer (with experience in analytical chemistry) to assist the Director with animal nutrition experiments—The Secretary, Rowett Research Institute, Bucksburn, Aberdeenshire (May 21).

Mining Engineers or Mining Surveyors in the Production Department at London headquarters—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, endorsed TT/310 (May 21).

Physicists or Mathematical Physicists: (Ref. A.133/51A) Principal Scientific Officer with experience of radar systems analysis and war-time operational research, (Ref. A.134/51A) Senior Scientific Officer for theoretical investigations; Aeronautical Engineer: (Ref. C.217/51A) Senior Scientific Officer with experience in planning and analysis of flight trials and application of results to project design; Physicists, Mathematicians or Engineers: (Ref. A.135/51A) Senior Scientific Officer with research experience involving arithmetical applications of mathematics in the analysis of physical data and the formulation of problems for solution by automatic computing machinery, (Ref. A.136/51A) Senior Scientific Officer with wide experience of methods of measurement in physics or engineering research; at the Royal Aircraft Establishment, Farnborough—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (May 24).

Research Studentships in Scientific Subjects—The Registrar, The University, Manchester 13 (July 1).

Assistant Superintendent of Public Works and Water Engineer by the Government of Grenada, Windward Islands—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M.25158.A.

Senior Scientist with experience in rubbers, resins and plastics—The Director of Research Personnel, Defence Research Board, Department of National Defence, 'A' Building, Ottawa, Canada; or Defence Research Member, Canadian Joint Staff London, Moncorvo House, 66 Ennismore Gardens, London, S.W.7.

Surveyor in the Lands and Mines Department, British Solomon Islands Protectorate—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting 27076/46/50.

Surveyors to carry out topographical and cadastral surveys in Malaya—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting 27076/28.